ENGINEERING DEVELOPMENT DIRECTORATE

ACCOMPLISHMENTS IN SUPPORT OF THE 1997 KSC IMPLEMENTATION PLAN

The NASA Vision

NASA is an investment in America's future. As explorers, pioneers, and innovators, we boldly expand frontiers in air and space to inspire and serve America and to benefit the quality of life on Earth.

Human Exploration and Development of Space Mission

To open the space frontier by exploring, using, and enabling the development of space and to expand the human experience into the far reaches of space.

Space Science Mission

To seek answers to fundamental questions about the galaxy and the universe, the Sun-Earth-heliosphere connection, origin and evolution of planetary systems, and origin and distribution of life in the universe. To enhance science, mathematics, and technology education and the technological literacy of all Americans. To develop, use, and transfer technologies that provide scientific and globally competitive economic returns to the Nation.

Mission to Planet Earth Mission

To develop understanding of the total Earth system and the effects of natural and human-induced changes on the global environment.

Aeronautics and Space Transportation Technology Mission

To pioneer the identification, development, verification, transfer, application, and commercialization of high-payoff aeronautics and space transportation technology.

DIRECTOR'S MESSAGE

This is the Engineering Development Directorate (DE) Annual Report for the period of June 1, 1996, through May 30, 1997.

The purpose of this report is to delineate and communicate the accomplishments of this Directorate, to facilitate the evaluation process for this period, and to help plan our work for the next year. The report has been organized around the goals and objectives of the 1997 KSC Implementation Plan and shows how DE supports the overall KSC mission and the four NASA strategic enterprises.

We have made significant contributions to KSC and the Agency. Each of us has taken the responsibility to continue to look for creative ways to support the goals and objectives of KSC and the Agency so that the value that we add is maximized.

The efforts of everyone in DE are appreciated and reflected in this report. Please let me know if you have any suggestions for improvement. Requests for additional copies of this document may be obtained through the Engineering Documentation Center (EDC) or accessed through the DE homepage on the World Wide Web (WWW).

Sterling W. Walker
Director, Engineering Development

ENGINEERING DEVELOPMENT DIRECTORATE

The Engineering Development Directorate (DE) plays a major role in developing and providing the systems, equipment, hardware, and technical expertise necessary for KSC to fulfill its mission of preparing and launching flight hardware in a safe and efficient manner.

DE performs work for a wide variety of customers including Shuttle Operations, Payloads Processing, and the International Space Station. Customer satisfaction and quality products continue to be a priority.

DE also plays a significant role in the development of advanced space transportation and the commercialization of space-related technologies.

The functional areas covered in this report include the following:

Technology Programs and Commercialization Office
Future Vehicles and Advanced Programs Office
Checkout, Control and Data Software Division
Checkout, Control and Data Hardware Division
Automated Intelligent Systems Division
Instrumentation Division
Mechanical Ground Support Equipment Division
Development Testing Laboratory
Project Control Office
Administrative Office
Engineering Support Contractor (I-NET)

Programmatic Assignments

Advanced Programs and Small Business Innovative Research
Advanced Space Transportation
Commercial Technology Program

Agency Support Activities

Expert Center for Workstation Management
Expert Center for Intracenter Networking

Cross-Cutting Functions

Education Programs
Public Affairs
Administration and Human Resources
Applied Technology Development and Technology Commercialization
KSC Laboratories and Testbeds
Process Analysis and Improvement
Information Technology Management
ISO Project Management

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ABBREVIATIONS AND ACRONYMS

AHS	American Helicopter Society
AIAA	American Institute of Aeronautics and Astronautics
ALS	Advanced Life Support
ALSARM	Advanced Life Support Automated Robotic Mechanism
ANS	ATM Network Switches
AOBD	Acousto-Optic Beam Deflector
APCU	Auxiliary Power Converter Unit
APTMS	Advanced Payload Transfer Guidance System
ARIS	Active Rack Isolation System
ASC	American Society for Composites
ASCE	Airlock Signal Conditioning Electronics
ASDL	Advanced Systems Development Laboratory
ASI	Agenzia Spazile Italiana
ASM	American Society of Metals
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ASTP	Advanced Space Transportation Program
ASTT	Aeronautics and Space Transportation Technology
ATE	automated test equipment
ATM	Asynchronous Transfer Mode
ATPS	Automatic Tile Processing Navigation System
AWID	Automated Window Inspection Device
BPC	Biomass Production Chamber
CAD	computer-aided design
CASE	Confined Access Support Equipment
CCAS	Cape Canaveral Air Station
CCF	Converter Compressor Facility
CCTV	Closed Circuit Television
C&DH	Command and Data Handling
CDR	critical design review
CEEK	Cargo Element Extension Kit
CELSS	Controlled Ecological Life Support System
CEWS	cargo element workstand
CFC	chlorofluorocarbon
CG	center of gravity
CGC	cold gas compression
CHEK	Cargo Handling Equipment Kit
CLCS	Checkout and Launch Control System
CLIM	Cable Line Inspection Mechanism

ABBREVIATIONS AND ACRONYMS (cont)

CM	Configuration Management
CMS	Coordinate Measurement System
CO_2	carbon dioxide
CoF	Construction of Facilities
COTS	commercial off the shelf
CRCA	component refurbishment chemical analysis
CSA	Canadian Space Agency
C&TCS	Communications and Tracking Checkout System
dc	direct current
DCR	design certification review
DE	Engineering Development Directorate
DEAP	Dryden Early Access Platform
DMES	dimethylethoxysilane
DOD	Department of Defense
DOF	degree of freedom
DRR	data review room
DSM	Dutonium 236 Space Modulator
DSP	Digital Signal Processor
DTL	Development Test Laboratory
DTV	digital television
ECIN	Expert Center for Intracenter Networking
EDC	Engineering Documentation Center
EE	end-effector
EELV	Evolved Expendable Launch Vehicle
ELV	Expendable Launch Vehicle
EMC	electromagnetic control
ERSMK	Element Rotation Stand Modification Kit
ESA	European Space Agency
ET	External Tank
FAA	Federal Aviation Administration
FAMU	Florida A&M University
FAR	Faculty Awards for Research
FCC	Federal Communications Commission
FDDI	Fiber Distributed Data Interface
FGSE	fluid ground support equipment
FNBIC	Florida/NASA Business Incubation Center
FRED	Fast Retrieval Enterprise Data

ABBREVIATIONS AND ACRONYMS (cont)

FRF	flight readiness firing
FRR	Flight Readiness Review
FSU	Florida State University
FTIR	Fourier Transform Infrared
FTXS	FDDI Transmission System
GH_2	gaseous hydrogen
GHe	gaseous helium
GIM	Ground Interface Module
GLTS	Gas Leakage Test Stand
GMS	ground measurement system
GN_2	gaseous nitrogen
GOX	gaseous oxygen
GSDE	Ground Support Design Engineering
GSE	ground support equipment
GSFC	Goddard Space Flight Center
GSPN	Ground Systems Pneumatics
GSRP	Graduate Student Research Program
HAK	Hatch Access Kit
HAS	Hatch Access Structure
HCI	Human Computer Interface
HDTV	High Definition Television
HEDS	Human Exploration and Development of Space
HEPA	High Efficiency Particle Accumulator
HFIS	HEPA Filter Inspection System
HMF	Hypergol Maintenance Facility
hp	horsepower
HVAC	heating, ventilating, and air conditioning
Hz	hertz
ICD	Interface Control Document
ICE	Intelligent Component Expert
IEA	Integrated Electronics Assembly
IEEE	Institute of Electrical and Electronics Engineers
IFAS	Intelligent Fracture Analysis System
INWG	Internet Network Working Group
IPT	Integrated Product Team
IR	infrared, Isolation Router
IRA	Institute Research Awards
ISO	International Organization for Standardization
ISPR	International Standard Payload Rack

ABBREVIATIONS AND ACRONYMS (cont)

ISS	International Space Station
IT	Information Technology
IVHM	Integrated Vehicle Health Monitoring
JGOAL	Java PCGOAL
JJ	Biomedical Operations Office
JMICB	Joint Management Integrated Control Board
JSC	Johnson Space Center
KHB	Kennedy handbook
KSC	John F. Kennedy Space Center
KSDN	Kennedy Switched Data Network
LAN	Local Area Network
LC	launch complex
LCC	Launch Control Center
LCCA	Lead Center for Communications Architecture
LeRC	Lewis Research Center
LES	Launch Equipment Shop
LETF	Launch Equipment Test Facility
LFBB	Liquid Fly-Back Booster
LH_2	liquid hydrogen
LHe	liquid helium
LMSW	Lockheed Martin Skunk Works
LN_2	liquid nitrogen
LO_2	liquid oxygen
LOX	liquid oxygen
LPIS	Launch Package Integration Stand
LPS	launch processing system
LSU	Louisiana State University
MACE	MPLM access certification equipment
MACS	Mobile Automated Cleaning System
MCSA	motor current signature analysis
MEIT	Multi-Element Integrated Test
MID	Mission Integration Document
MILA	Merritt Island Launch Area
MLI	multilayer insulation
MLP	Mobile Launcher Platform
M&P	Materials and Processes
mph	mile per hour
MLPM	Mini-Pressurized Logistics Module
MPS	Main Propulsion System
MSBLS	Microwave Scanning Beam Landing System

ABBREVIATIONS AND ACRONYMS (cont)

MSD	Materials Science Division
MSFC	George C. Marshall Space Flight Center
MTDE	Mission to Planet Earth
NAK	Node Access Kit
NASDA	National Space Development Agency of Japan
NDE	nondestructive evaluation
NDS	Network Documentation System
NSTS	National Space Transportation System
O&C	operation and Checkout
OCR	Operational Control Room
OIS-D	Operational Intercommunications System - Digital
OMI	Orbital Maneuvering Subsystem
OPC	Organic Photo Conducting
OPF	Orbiter Processing Facility
ORU	Orbital replaceable unit
OTV	operational television
PAMS	Portable AFT Mass Spectrometer
PAWS	Paging and Area Warning System
PCIS	Project Control Information System
PCR	Payload Changeout Room
PDR	Preliminary Design Review
PDSCWFRS	Parabolic Dish Solar Collector Waste Fluid Reduction System
PDSS	Payload Data Services System
PGOC	Payload Ground Operations Contractor
PHSF	Payload Hazardous Servicing Facility
PIH	Payload Integration Hardware
PIPS	Payload Inspection and Processing System
PLAK	PLM Late Access Kit
PLAP	PCR Late Access Platform
PLM	Pressurized Logistics Module
PMA	Pressurized Mating Adapter
PMS	Permanent Measurement System
POCS	Photo Optical Control System
POIC	Payload Operations Integration Center
POP	Program Operating Plan
PRACA	Problem Reporting and Corrective Action
psi	pound per square inch
psig	pound per square inch gage

ABBREVIATIONS AND ACRONYMS (cont)

PTCS	Payload Test and Checkout System
QD	quick disconnect
RAS	Rack Access Stands
R&D	Research and Development
RDDC	Rack Drawer Delivery Cart
RDH	Rack Drawer Handler
REAP	Removable End Access Platform
RF	radio frequency
RID	rack insertion device
RLV	reusable launch vehicle
RMAS	Remote Monitor and Alarm System
RME	Risk Mitigation Experiment
ROAP	Removable Overhead Access Platform
RSA	Russian Space Agency
RS&H	Reynolds, Smith & Hill, Inc.
RSRM	Redesigned Solid Rocket Motor
RTI	Research Triangle Institute
RTLS	return to launch site
SAEF	Spacecraft Assembly and Encapsulation Facility
SBIR	Small Business Innovative Research
scfm	standard cubic feet per minute
SE	support equipment
SFMT	Shuttle Facility Modification Team
SGSTS	Space to Ground Subsystem Test Set
SLC	Space Launch Complex
SLF	Shuttle Landing Facility
SLWT	Super Light-Weight Tank
SONET	Synchronous Optical Network
SPP	Science Power Platform
SRB	Solid Rocket Booster
SRM	Solid Rocket Motor
SSC	Stennis Space Center
SSE	Space Science Enterprise
SSET	SRM Stacking Enhancement Tool
SSGLCS	Supersonic Gas-Liquid Cleaning System
SSME	Space Shuttle Main Engine
SSFP	Space Station Processing Facility
STDN	Space Tracking and Data Network
SUD	SSFP Utilization Document
SVS	Space Vision System

ABBREVIATIONS AND ACRONYMS (cont)

TA	task agreement
TAL	Transatlantic Abort Landing
TCMS	Test, Checkout, and Monitor System
TENSIR	Tendon Supported Inspection Robot
TIM	Technical Interchange Meeting
TM	Technical Memorandum
TSM	Tail Service Mast
UCF	University of Central Florida
USA	United Space Alliance
USCA	Universal Signal Conditioning Amplifier
USICU	United States International Standard Payload Rack Checkout Unit
USOS	U.S. Operations Center
UV	ultraviolet
V	volt
VAB	Vehicle Assembly Building
VAFB	Vandenberg Air Force Base
VETA	Verification Test Article
VFD	variable frequency drive
VHOK	Vertical Hatch Operations Kit
VPF	Vertical Processing Facility
WISE	Women in Science and Engineering
WOMI	Wireless Operation and Maintenance Instructions
WSG	Wide Area Network Security Gateway
WSK	Water Servicing Kit
WSTF	White Sands Test Facility
WWW	World Wide Web

INTRODUCTION

PURPOSE

The purpose of DE's annual report is to document how the Directorate has carried out the KSC, NASA, and Enterprise Strategic Plans through implementation planning, execution, and performance evaluation of assigned tasks. This report conveys how DE integrates the deployment of cross-cutting functions with the primary functions in order to effectively execute our assigned activities. The activities identified in this report have been carried out through the dedication of the people in DE. DE's activities will be modified appropriately to reflect changes in future KSC, NASA, and Enterprise strategic direction as well as KSC's implementation of the strategies.

PROGRAMMATIC ASSIGNMENTS

Although DE provides support across KSC, the following list provides a brief summary of the program assignments that DE has responsibility for:

Advanced Programs and Small Business Innovative Research (SBIR) -
DE manages and administers program funds which demonstrate proof of concept for new and applied aerospace technologies necessary to process and launch current and future vehicles.

Advanced Space Transportation -
DE develops and demonstrates proof of concept for new and applied aerospace technologies necessary to process and launch future vehicles.

Commercial Technology Program -
DE has established several aggressive commercialization programs that successfully transfer NASA technologies to private industry. Included are Technology Transfer, NASA/Florida Business Incubator, University Research, and Dual Use.

AGENCY SUPPORT ACTIVITIES

Agencywide support activities assigned to KSC reduce duplication of effort, enhance performance, and reduce overall operational costs. DE's contributions to these Agency support roles are described in Section V of this document.

KENNEDY SPACE CENTER (KSC) CROSS-CUTTING FUNCTIONS

KSC employs cross-cutting functions to enable implementation of NASA's objectives. DE's contributions to these essential activities are described in Section VI.

EMPLOYEE AND IMPLEMENTATION PLAN RELATIONSHIP

The employee's performance plan will have a direct relationship to the plans outlined in the KSC Implementation Plan. Through this link, each performance plan will be supportive of NASA Strategic Planning. It is important for every employee to understand how his/her efforts support the roles and mission of NASA.

SECTION I

KSC SPECIFIC ROLES IN SUPPORT OF THE HUMAN EXPLORATION AND DEVELOPMENT OF SPACE (HEDS) ENTERPRISE

HEDS ENTERPRISE GOAL 1
Increase human knowledge of nature's processing using the space environment

HEDS Enterprise Objective 1.1:
Understand the fundamental role of gravity and the space environment in biological, chemical, and physical systems

KSC Future Plans:

- Provide engineering and science expertise in future launch vehicle programs

DE Accomplishments:

- Provides engineering and science expertise in the Evolved Expendable Launch Vehicle (EELV) and X-33/X-34 technology demonstrator programs. DE has performed hydrogen entrapment and cryogenic/pneumatic system studies in support of ongoing development of the EELV. DE is also designing significant portions of X-33 ground support equipment including Ground Interface Modules (GIM's), umbilicals, and holddowns. DE is also supporting the X-33 Environmental Impact Statement effort. DE is taking the lead accommodating the X-34 flight test program at the Shuttle Landing Facility (SLF) by providing a maintenance capability and other services required by X-34.

- Via Task Agreements (TA's) with Lockheed Martin Skunk Works (LMSW), designing the following umbilical subsystems for the X-33 program: mate/retract, alignment mechanism, and blast door mechanism. In addition, we are providing design support for the flexhoses, flexhose management system, fluid interface panels layout, and fluid systems integration. DE has also been tasked to design the Vehicle Positioning System, which will maneuver the vehicle into its mating position, and the Holddown Post System, which will provide mounting points for the vehicle in both mated positions.

- Began Launch Equipment Test Facility (LETF) support equipment conceptual design and facility preparations. Modifications have also begun in support of system qualification testing of the Liquid Hydrogen Umbilical Plate and subsystem (including flight and ground halves), the Liquid Oxygen Umbilical Plate and subsystem (including flight and ground halves), and the Holddown Post subsystem. Unlike previous test programs which used prototype or test

articles, the umbilical testing will involve ambient and cryogenic functional performance of the program's actual flight and ground plates, flexhoses, and quick disconnect (QD) fluid connectors. Similarly, the holddown post testing will use the actual ground hardware. DE will also be designing all LETF special test fixtures. Fabrication will be performed by the Engineering Development Contractor.

- Additional accomplishments in support of the X-33 program include:
    - Provided design concepts for the Preliminary Design Reviews (PDR's) for both the flight and ground systems reviews, held at LMSW-Palmdale in November and December 1996.
    - Provided design packages for the 60 percent design review, held at LMSW-Palmdale in April 1997.
    - Supported the propellants and gases ground systems preliminary design reviews with Sverdrup in October 1996 and February 1997.
    - Assisted United Space Alliance (USA) Ground Support Design Engineering (GSDE) in preparing the Interface Control Document (ICD) for the flight and facility interfaces for the propellants and gases.
    - Prepared a proposal for liquid oxygen (LOX) asphalt testing and risk assessment and submitted the proposal to LMSW in October 1996.
    - Analyzed the launch dynamics of the X-33 carrier plate. The carrier plate contains the critical fluid and electrical connections to the X-33 vehicle. The dynamic motion of the carrier plate during launch influences loads and timing of other ground support equipment (GSE). The stresses in the plate during mating and demating were also analyzed.
- Performed extensive reviews/evaluations of the proposed flame deflector, acoustic/overpressure, unburned hydrogen, and propellant farm designs in regard to the EELV program. Design concepts for a hydrogen dispersion system using liquid nitrogen, a flame deflector, and a flame trench (including acoustic suppression) were submitted in August 1996.
- Performed acoustic predictions for EELV. The predictions were used in tradeoff studies for determining the optimum launch pad configuration. This work was executed in support of McDonnell Douglas.
- Developed a rise-off umbilical system for use with future launch vehicle ground support systems. (See HEDS Objective 3.3)

- Provided umbilical systems consultations to NASA Johnson Space Center (JSC) White Sands Test Facility (WSTF) and Boeing developers of the Bantam Booster. (See HEDS Objective 3.3)

- Providing information on the design and utilization of the Mobile Launcher Platform (MLP) to the Boeing Commercial Space Company for the Sea Launch Program.

HEDS Enterprise Objective 1.2:
Use HEDS research facilities innovatively to achieve breakthroughs in science and technology

- Conduct a vigorous peer-reviewed basic research program using both flight-based and ground-based facilities to achieve breakthroughs in science and technology
- Establish a global framework for the integration of research programs and facilities

KSC Implementation Plans:

- Utilize KSC-unique facilities and capabilities to develop, verify, and validate new technologies for enhancing ground and launch operations
- Continue to offer and utilize the specialized skill, expertise, and equipment of the KSC Development Test Laboratory (DTL) for services such as:
    - Construction of a Russian Mir plant growth chamber mockup for training US astronauts
    - Fabrication of Controlled Ecological Life Support System (CELSS) for KSC biomedical research
    - Development and fabrication of Russian Mir gaseous nitrogen (GN_2) bottle simulator to demonstrate GN_2 transfer and recharge from U.S. equipment to Russian Mir flight hardware

DE Accomplishments:

- 2-Phase Quality/Flow Meter Project: Continued development on the 2-Phase Quality/Flow Meter. The current project involves a dual-use project with Air Products to commercialize the meter for use on cryogenic liquid nitrogen systems. Technically, the project is going well. If funded, 10 of these meters will be produced for use at NASA centers on liquid oxygen (LO_2) and liquid hydrogen (LH_2) transfer systems. In addition, tested a parallel developed 2-Phase Quality Cryogenic meter (improved prototype) at the LETF and DTL. The unit was delivered to Air Products (the dual-use partner) in Allentown, PA, for extensive flow testing. This is an improved prototype of the commercial version. (See HEDS Objective 4.1)

- Turbine/Brush Cleaner system:
    - Transferred technology of innovative cleaning system to a small startup business. The Eastman Company has expressed an interest in the device to clean aluminum pipes used in process plants. Redesign and optimization is ongoing, with the University of Central Florida (UCF) providing support in Rapid Prototyping using Stereo-lithography.

- Assisted Johnson Controls with a problem in the Titan launch structure. The four Space Launch Complex (SLC)-41 Bogie Jacks lift and position the Titan launch structure. The pistons in the 10,000 pound per square inch (psi) hydraulic jacks failed and each attempt to repair the piston failed the pressure test. Designed a new piston ring which reduces friction and withstands the required pressure. The new design is also cheaper to manufacture.

- Completed the Verification Test Article (VETA) project, Phase 1. The VETA utilizes a test structure at Launch Complex (LC) Pad 39A to measure loading and vibrations due to Space Shuttle launches. The purpose of the gathered data is to validate vibro-acoustic GSE design methods developed at KSC as a result of 10 years of research. The results are being reported on a NASA Technical Memorandum (TM), and will be submitted to the 5th International Congress on Sound and Vibration for peer review. Phase 1 consisted of measuring VETA data for five launches and using the developed methods to compare the VETA's actual with its analytical response. Phase 2 will consist of gathering six more launches of data for further studies into the effects of launch trajectory on loading and response of GSE.

- Completed SBIR with Aerospace Design and Development to develop a new cryogenic thermal insulation to replace compatible perlite.

- Represented Kennedy Space Center on the Engineering Management Council Structural Design, Analysis, Test, and Verification Steering Committee. The Steering Committee recommends priorities and funding for research projects in the stated emphasis area to the NASA Chief Engineer.

- Developed and documented several analytical tools and methods that have been used in the design and evaluation of cryogenic transfer systems:
    - Developed a computer program for determining the potential of geysering in vertical cryogenic transfer piping.
    - Developed a computer program for selecting the optimum size of vacuum jacketed transfer piping to meet system flow requirements.

  - Developed a computer program for evaluating the effects of cryogenic two-phase flow transients.

  - Wrote a computer program for determining the flow pressure requirements for cryogenic systems.

  - Wrote a computer program for determining the temperature rise in cryogenic transfer systems.

  - Determined the possibility of cryogenic pumping of air into hydrogen flare stacks when flowing liquid hydrogen into a warm nitrogen purge gas.

  - Developed a hydrogen vent system that will prevent drawing air into hydrogen subcooling systems. The system uses evaporative cooling to take the hydrogen tank ullage below its triple point.

- Performed tests of Shuttle components and potential replacements at both the DTL and the LETF under the Component Test Program, in support of both existing problems and future planning. The DTL has the largest cryogenic test facility at KSC, with a capacity of 6000-gallons of liquid nitrogen. In addition, the DTL has a 9000-psi gaseous nitrogen test facility.

- Completed the design of the Main Propulsion System (MPS) LOX Pump Test Facility at the LETF in January 1997. Piping spool piece fabrication, pump modifications, pump/motor baseplate fabrication and installation, and pump/motor installation were also completed. The motor current signature analysis (MCSA) tool was procured and successfully tested on the 75-horsepower (hp) pump in the fluid test loop. During facility buildup, NASA Operations requested a special test of the new Allen-Bradley variable frequency drives (VFD's) to determine the auto restart capability. The tests were completed using a dynamometer in place of the LOX pump. The results of the tests will be used in evaluation of replacing the current Robicon VFD's at LC39.

- Completed an engineering test and evaluation of a PHPK Technologies, Inc. cryogenic globe valve in November 1996. The test article was a Model PV-60-20-G-nonstraight pattern globe valve (2-inch, 600 psi). The primary objective of the testing was to determine the internal leakage rate of gaseous helium at liquid nitrogen temperature. The secondary objection was to assess the overall integrity of the valve and its mechanical operation. This work was done in support of the Converter Compressor Facility (CCF) Liquid Helium Supply project.

- Completed an engineering test and evaluation of a Worcester Controls Series 52 Ball Valve in November 1996. The primary objective of the testing was to

determine if high static pressures on the downstream seat for extended periods of time would then cause the valve to leak gaseous helium at low upstream pressures. This work was done in support of the CCF Liquid Helium Supply project.

- Calibrated the Helium Ultrasonic flowmeter with the vendor's support. A flow measurement of 0.1 to 7.0 cubic feet per minute on a 3000-psi LETF fabricated prototype was demonstrated. The vendor was given modification requirements to allow the meter to measure over the full flow range.

- Demonstrated machinery health monitoring using vibration, acoustic emission, and motor current methods using a vendor-supplied data acquisition system. Data was collected on the 75-hp water flow loop with known bearing flaws in the pump. This data was analyzed using these methods to show their health monitoring capabilities.

- Wrote two NASA Technical Memorandums on component testing projects. They are entitled:

    - Non-Intrusive Flow Rate Determination Through Space Shuttle Water Coolant Loop Floodlight Coldplate. March 1997

    - Space Shuttle Hypergol Load Determination Using Non-Intrusive Ultrasonic Flowmeters. September 1996

HEDS ENTERPRISE GOAL 2
Explore and settle the Solar System

HEDS Enterprise Objective 2.1:
Enable human exploration through Space Science Enterprise robotic missions
- Characterize solar system bodies, including the Moon, Mars, and asteroids, to enable planning for human activities
- Demonstrate technologies required to use extraterrestrial resources

KSC Future Plans:
- Participate as a support Center to the NASA Center of Excellence for Planetary Robotics

HEDS Enterprise Objective 2.2:
Expand human presence in space by assembling and operating the International Space Station (ISS)
- Execute the phase I program of the ISS
- Build and deploy the ISS

- Conduct long-duration utilization and operations as a stepping stone to the space frontier

KSC Implementation Plans:

- Provide test instrumentation and KSC expertise to other Centers and international partners for factory tests, etc.
- Develop, activate, and validate ISS facility systems, ground support equipment, and processes to enable efficient launch site processing
- Provide launch site support to the Space Station assembly flight hardware developers
- Support customers in design and development of ISS hardware elements and utilization experiments to optimize launch site operations

KSC Future Plans:

- Develop and maintain a core group of flight systems specialists to support problem resolution for ISS on-orbit operations
- Maintain a core group of technical experts within NASA for ground processing (assembly, test, and checkout) to support future space flight programs

DE Accomplishments:

- Directly supports the Test, Checkout, and Monitor System Integrated Product Team (TCMS IPT) in the development of the hardware and software used in the KSC's checkout and test capability for Space Station modules prior to launch. This team has delivered to the Space Station Processing Facility (SSPF) both the hardware and software for the first phase of the checkout system. In June of 1996, the second major software release was delivered to the TCMS users, and it is currently being used for testing of Space Station modules as they arrive at KSC. Additional capability and functionality for the checkout system will be delivered over the next several years with the final capability planned to be in place by 1999.
- SSPF Vacuum Chamber: Supported a feasibility study and cost estimate in December 1996 to reactivate the Operation and Checkout (O&C) altitude chambers for use in processing Space Station pressurized modules. Cost and requirements were the major factors in concluding that a horizontal vacuum chamber located at the SSPF would be a better method of processing Space Station modules and future payloads. A study to provide funding on an accelerated schedule and a vacuum chamber specification was developed in March 1997. Further requirements reviews are presently being undertaken; to date, no funding has been allocated to start this major development and construction project.

- Created initial concepts for the vacuum chamber for Space Station. The weight and overall structural arrangement were estimated to verify the proposals submitted by interested companies.
- Performed design and implementation of a system which simulates and tests all ISS on-orbit interfaces with experiment racks to verify proper operation prior to launch.
- Performed design and implementation of systems for the Italian Mini Pressurized Logistics Module (MPLM) for SSPF checkout, launch pad checkout, landing convoy operation, and Orbiter Processing Facility (OPF) deservicing.
- Developed and demonstrated the operation of specialized test instrumentation to solve programmatic issues at assembly plants, development centers, etc.
- Developed, activated, and validated ISS facility systems, ground support equipment, and processes to enable efficient launch site processing.
- Managed and completed ISS Support Equipment- Communications and Avionics-IPT critical design review (CDR) Boards for the KSC SSPF Communications and Tracking Checkout System (C&TCS) and the Command and Data Handling (C&DH) Systems, which will provide high-fidelity simulations for prelaunch interface verification of ISS experiments during processing at KSC.
    - Ensured the fabrication, installation, and testing scenario development for these systems are on schedule to support the activation and validation testing of these and other subsystems that make up the Payload Test and Checkout System (PTCS) in the SSPF.
    - Managed and ensured delivery of program hardware and software products required for these systems in accordance with previously negotiated agreements.
    - Performed assessments of special integrated tests that the program has identified to be performed at and/or supported by KSC-developed support equipment and personnel.
    - Assessed George C. Marshall Space Flight Center (MSFC) Payload Data Services System (PDSS) and Payload Operations Integration Center (POIC) system architectures and developed a KSC implementation plan that maximizes use of MSFC system and mission-unique software products. Individual subsystem commercial

off-the-shelf (COTS) components have been identified and are in the acquisition phase.

- Developed the Communications and Tracking Checkout System (C&TCS) for the International Space Station, which completed a critical design review in August 1996. Procurement, fabrication, and installation of C&TCS have started with the first major purchase this year of the Ku-band front end processor used for initial processing and distribution of the ISS experiment payload data. The KSC-defined payload data generator and payload data analyzer were delivered by the Goddard Space Flight Center (GSFC). The C&TCS Video Test Set and Space to Ground Subsystem Test Set (SGSTS) have been received from the program.

- Continued to manage the Electrical and Instrumentation IPT. The team is responsible for the design and production of electrical GSE for ISS pre-launch testing. Major accomplishment of the team are as follows:
    - Special Test Equipment and Adapter Cables: Completed PDR and CDR for MPLM breakout boxes and adapter cables. Final updates to the design are in progress and fabrication is due to start in September 1997. Previously completed breakout boxes and adapter cables and ground straps were turned over in February 1997 for use on Flight 2A (Node 1) testing.
    - MPLM Flight Interface Cables: Completed PDR November 1996 and CDR March 1997. Advanced parts list was released in April 1997. Final updates to the design are in progress and fabrication is due to start in August 1997.
    - 28-VDC Power Ground Support Equipment: The 28 volt (v) direct current (dc) for the United States International Standard Payload Rack Checkout (USICU) was completed and transferred in November 1996. The 28-V dc heater power for MPLM checkout completed CDR in January 1997 and 100 percent design release in February 1997. Fabrication began in February 1997 and is scheduled for completion in January 1998.
    - 120 V dc Power Ground Support Equipment: The fabrication contract for the 120 V dc Pad/Runway T-0 Power Supply was awarded to Power Conversion Technology in September 1996. The prototype supply was tested at the factory in June 1997 with delivery to KSC expected in July 1997. If the prototype testing at KSC is successful, options in the contract for final design and production units will be exercised. A 120-V dc Primary Power Source and a Programmable Load were delivered by Rocketdyne to KSC in November 1996. A second 120-V dc Primary Power Source has been delivered.
    - 60-Hertz (Hz) Power: Turnover of the 15 original portable power distribution carts for the SSPF occurred in February 1997. Three

additional carts fabricated this year will be turned over in July 1997. Design of the 60-Hz mobile power generators to support MPLM power up at the Shuttle Landing Sites is scheduled to start in October 1997.

- Electro-Magnetic Control (EMC): The EMC certification review team for ISS at KSC met several times this year to review the test results on completed GSE. The ISS program EMC team was hosted at KSC earlier this year.
- The Sensor Development Laboratory presently has in the qualification process the Leybold Vacuum Controller, a replacement for the Granville-Phillips vacuum sensor, a combination pressure temperature transducer and a low-velocity pressure test system.
- Ammonia Sensing: The prototype ammonia sensing cart successfully supported the ammonia servicer testing at KSC. The two production units of the ammonia sensing cart are now completing fabrication and will undergo activation validation testing starting in January 98. The fabrication package for the payload canister ammonia sensing was released in May 1997, and the installation package has also been released.

- Continued to manage the simulators IPT. The team provides ground support equipment that simulates parts of the ISS that are on orbit or unavailable for prelaunch testing. Major accomplishment of the team are as follows:

  - United States International Standard Payload Rack (ISPR) Checkout Unit (USICU): USICU provides high-fidelity simulations of the Space Station interfaces to the ISPR and Expedite the Processing of Experiments To Space Station (EXPRESS) racks. DE is leading the development of the USICU. CDR was completed in July 1996. Installation is 80 percent completed as of June 1997. Activation/ validation plan was released in April 1997. Activation/validation will start July 1997 and be 90 percent completed December 1997. The remaining testing will be scheduled pending external deliveries. Turnover date of the USICU is scheduled for August 1999.

  - Payload Test and Checkout System (PTCS): PTCS is the integrated test configuration consisting of the USICU; Communication and Tracking Checkout System; Command and Data Handling; Test, Checkout, and Monitor System; and associated GSE used to checkout the ISPR/EXPRESS racks prior to launch. The Integration Plan was released March 1996 and Integration Drawing draft was released September 1996. PTCS activation/validation is scheduled for March 1999 to support flight UF1. DE will lead the integration development phase of the PTCS.

  - Node Emulator and Multi-Element Integrated Test (MEIT) Interconnect Cables/Quick Disconnects: Requirements are being base-lined. The design will be started immediately upon approval of the change order

and approval from the ISS program. DE will lead the development of the Node Emulator and MEIT Interconnect Cables/Quick Disconnects, which will be used to support functional testing of the 3A, 4A, 5A, and 6A elements of the ISS at KSC. Turnover date to operations is scheduled for July 1998.

- Support to other Integrated Product Teams was provided as follows:
    - MPLM Design Support: DE supported the electrical design efforts for the MPLM Fluid GSE (FGSE) by (1) review/redline/comment on Italian substituted specifications and as-built FGSE documents and (2) through telecons with the American/Italian "On-Site FGSE Review" team in Italy. DE is leading the design of software packages to help the Italians test the FGSE prior to delivering it to America. We are using the development of a Communications Interface Software Kernel and Simulation Software, part of our Test, Checkout, and Monitor Subsystem (TCMS), to accomplish this task. We are also supporting the efforts of our operational counterparts in helping develop application software and displays for use in the final KSC TCMS checkout and verification.
    - MPLM Design Support: Supported the subsystems design reviews for fluid systems for the Mini Pressurized Logistics Module. The GSE associated with the flight systems was also a part of these reviews; the following GSE completed its CDR's (RID review comments were verified by functional test and verification at Alenia, Italy, in May 1997): (1) Gas Leakage Test Stand (GLTS), manufactured by Daimler-Benz for European Space Agency (ESA); (2) U.S. Operations Center (USOS)/National Space Transportation System (NSTS) Thermal Simulator, manufactured by Microtechnica; and (3) Water Servicing Kit (WSK), manufactured by Microtechnica. A total of two sets each of this equipment will be shipped to KSC and will reside in the SSPF for checkout and testing of the MPLM.
    - MPLM Cooling Servicer: The GSE PDR was completed in April 1996, and a joint SSP/ISS end-to-end system review held at KSC in August 1996 established requirements and agreements, which led to a delta PDR in September 1996. A Joint Management Integrated Control Board (JMICB) in February 1997 concluded that a drain back of the freon prior to launch was not required; therefore, the design effort was redirected once again. The system design is now undergoing component selection, simplification, and requirements confirmation and is headed for a CDR in April 1998.
    - ESA Node: DE is currently helping our MSFC and prime counterparts in their efforts to present American support equipment capabilities to the Italian engineers building a second node for the ESA.

- Performed qualification testing on transducers for use in Space Station processing GSE at the SSPF.

- Provided design, procurement, fabrication, assembly, test, installation, and integration support for the following ISS rack handling and access equipment and fluid servicing equipment:

  - Rack Insertion Device (RID): The RID is used to install and remove ISS equipment racks from the MPLM. DE supported the RME 1313 payload operation (Risk Mitigation Experiment using the Active Rack Isolation System-ARIS) for the STS-79 SpaceHab Mission by accelerating the final design and fabrication phase of the project and providing the equipment 12 months ahead of schedule. The RID also supported the deintegration of the ARIS after flight. Provided the kinematic, stress, and deflection analysis for the RID weight and center of gravity (CG) system. The weight and CG system mounts on the end of the RID and measures the weight and the three-dimensional center of gravity of a Space Station rack. The instrumentation layout was devised for the maximum possible accuracy of CG. The system can measure the CG location of the rack in any position without measuring the rack orientation. (See appendix A.)
  - RID End Effectors: Additional access and handling capabilities for ISS equipment processing have been designed, fabricated, and tested for incorporation into the RID system. A prototype weight and CG end effector, designed and fabricated by DE, was successfully tested, providing repeatable, accurate weight and center of gravity measurements for the test rack. Critical Design Reviews for the orbital replaceable unit (ORU) end effector and the personnel access end effector were completed in April 1997. The aisle stowage container end effector operational flow/design concept was completed. The CDR was completed in November 1996, and the 100 percent design package was released in December 1996. A study to assess rack installation through the node 50-inch hatch was completed (a 50-inch hatch end effector for the RID is under consideration for the operation). The CDR package was released in March 1997, and the CDR was completed in April 1997. (See appendix A.)
  - RID Air-Bearing Handling Equipment: Air-bearing pallets were modified, successfully tested, and installed in the SSPF high bay. The pallets are used to move the RID within the Space Station Processing Facility during processing operations.
  - Cargo Element Workstands (CEWS): Six 15-foot CEWS, used to support, access, test, and inspect ISS cargo elements, were completed and delivered to KSC. A formal Design Certification Review (DCR) and turnover of the equipment were also completed.

- MPLM Access Certification Equipment (MACE): The MPLM mockup forward end cone, skin supports, and skin fabrications were completed. The MACE support stand fabrication was also completed. Final assembly of the MACE is in work. New requirements for ISS 2A late access training were approved by MSFC. Design concepts to upgrade the MACE for high-fidelity flight mockups, a Pressurized Mating Adapter (PMA) mockup, Resource Node outfitting mockups, and Node Access Kit (NAK) support structure were completed. Four new GSE end items to be used for node and PMA access were identified, concepted, and approved: Personnel Access Platform, NAK, Vertical Hatch Operations Kit (VHOK), and Node Aft Hatch Access Kit (HAK). (See appendix A.)
- Late and Early Access Equipment: Both the McDonnell Douglas PLM Late Access Kit (PLAK) and the Lockheed Martin PCR Late Access Platform (PLAP) designs were completed, and the fabrication contracts have been awarded. The Hatch Access Structure (HAS), Cargo Handling Equipment Kit (CHEK), and the Dryden Early Access Platform (DEAP) Critical Design Reviews were completed.
- Rack Access Equipment: Designs were completed and fabrication contracts awarded for the Rack Access Stands (RAS), Rack Drawer Delivery Cart (RDDC), and the Rack Drawer Handler (RDH).
- Removable End Access Platform (REAP): The REAP will be used for access to the ends of and into the MPLM both while in the Orbiter at the OPF (early access) and during SSPF processing. A fabrication contract was awarded and is underway.
- SSPF Workstands: The final Design Certification Review and turnover were completed for the Launch Package Integration Stand (LPIS), Aft Flight Deck Stand, Time-Zero Stand, Payload Fittings, Work Access Stairs, Cable Tray Stands, Removable Overhead Access Platform (ROAP), Rack Electric Forklifts, Personnel Lifts, and Alignment Equipment.
- Element Rotation Stand Modification Kit (ERSMK): The design was completed and procurement of kit materials is underway by McDonnell Douglas.
- Convoy Support Vehicle: A study identifying facility modifications required to operate the Convoy Support Vehicle (PMN GX5-00875) was completed.
- Confined Access Support Equipment (CASE): The CASE will include personnel support items such as communication equipment, air conditioning, lighting, and other items.
- The Auxiliary Power Converter Unit (APCU) Payload Integration Hardware (PIH) is a device that provides active cooling of the flight APCU

when it is powered up in the Launch Package Integration Stand. It is comprised of a cooling cart and a portable cart assembly. The APCU is mounted to a portable cart that incorporates a heat exchanger for cooling the APCU. The heat exchanger is connected to the cooling cart with a closed water loop. The cooling cart, modified from a surplus Spacelab cooling cart, is coupled to the facility chilled water loop to dissipate the heat from the APCU. The APCU-PIH was completed in March 1997. Activation/validation was completed in April 1997. The device is ready to support flight 2A.

- Cargo Element Extension Kit (CEEK): The CEEK spacer set will be used to raise the height of the node for alignment access in the CEWS and the LPIS. The design was completed, and a fabrication contract was awarded.
- Ammonia Servicing System: The ammonia servicing underwent activation/validation from June through September 1996. The equipment was shipped in October 1996 to the Lockheed Martin plant in Denver, Colorado, for use with PG-2 GSE for support of ground-level qualification and hardware/software integration testing of the Integrated Electronics Assembly (IEA) before and during vacuum chamber testing. The ammonia system has supported numerous loadings and will be utilized at Denver for future loads through August 1997. At completion of PG-2 testing, the system will be returned to KSC for modification/repair and will be ready for LSU turnover in January 1998. (See appendix A.)
- Cold Cargo Transport Equipment: The Cold Cargo Transport Equipment is required to transport the conditioned cargo from the SSPF or Hangar S to the launch pad for installation into the refrigerated freezers located inside the MPLM. Due to rephasing of the manifest and the slip of the first active flight of the refrigerator/freezers on UF-3, the project design does not start until 1999.
- Russian Science Power Platform: A Technical Interchange Meeting (TIM) was held with the Russians in August 1996 to discuss the feasibility of using the KSC Ammonia Servicing System to load ammonia on their Science Power Platform (SSP) module. Further discussions and operational and technical considerations were performed in a follow-on TIM held at KSC in March 1997. The use of the Ammonia Servicing System is required for loading the SSP in May 2001.

- Provide input to the SSPF Utilization Document (SUD), which is updated quarterly. The SUD was developed to provide graphical layouts and pictorials of the SSPF high bay from 1996 through 2002. High bay processing is provided for Spacelab hardware, Space Station elements, Russian Mir elements, and other United States and international flight hardware. The layouts are used to determine locations of flight hardware processing, to determine footprint requirements, to verify equipment

availability, and determine facility requirements. The flight processing locations are then used to develop more detailed definition in the Mission Integration Document (MID).

- Review the MID on a quarterly basis. The MID has been created to determine detailed ground processing data needed to process Space Station flight hardware. The data, which includes GSE locations, cable and fluid line interface diagrams, cable and fluid line responsibilities, and other information, is used by NASA, Alenia, and Boeing design organizations to determine GSE requirements and cable length limitations. The data will also be used to install and verify flight equipment and GSE configurations.
- Perform lead responsibilities for Access and Handling, and Fluids and Services for the support equipment (SE) provided by KSC and product groups at the launch site for prelaunch and postlanding processing of ISS elements in support of the Space Station Support Equipment Integrated Product Team (SE-IPT).
- Perform lead responsibilities for the Shuttle Facility Modification Team (SFMT). This team is responsible for the integration of all ISS/Shuttle GSE issues, operations, and Shuttle facility modifications. The team provides project management for all the engineering and operations requirements of ISS missions into Shuttle facilities and processing operations.

HEDS Enterprise Objective 2.3:
Develop biomedical knowledge and technologies to maintain human health and performance in space

HEDS Enterprise Objective 2.4:
- Establish a human presence on the Moon, in the Martian system, and elsewhere in the inner Solar System
- Develop life support and other human support technologies and advanced systems to achieve exploration goals
- Develop innovative advanced technology to support human exploration
- Conduct prototype, advanced-development demonstrations to ensure feasibility of the exploration strategy

KSC Implementation Plans:
- Develop and bring online a new launch processing system which reduces launch processing costs and meets future launch vehicle needs
- Develop tools, techniques, and improved processes to provide more cost-effective payload processing and Space Station resupply/return functions
- Capitalize on synergy between programs to insert technology and develop new tools to improve safety, reliability, and processing time

- Provide an operational environment for concept feasibility assessment, validation, and implementation of advanced technologies
- Using the Advanced Life Support capability developed at KSC, continue to support the Lead Center to gain knowledge of long-term plant growth in space in support of Space Station
- Conduct focused research directed at biological systems for use in regenerative life support systems

KSC Future Plans :

- Develop proof-of-concept automated and intelligent systems tools for vehicle systems performance analysis, operations, and future launch systems evaluation
- Support advanced technology for propulsion systems in the areas of propellants and radiological power sources
- Develop launch structures, systems, and operations support equipment for manned and/or remote operations in low gravity environments
- Develop the necessary test facilities, simulators, and analysis tools to demonstrate proof of concept for low gravity launch structures

DE Accomplishments:

- Investigate advanced development prototypes of possible future technologies that could aid in establishing human presence on other bodies in the solar system. These activities include technologies such as rough logic algorithm.

  Rough logic algorithm development, which shows a potential for being included in autonomous systems that requires a great deal of independence and the ability to deal with greater levels of uncertainty in remote locations. Rough logic algorithms could be used to train neural networks in complex machines that have limited human access.

  A preliminary design of rough logic algorithms has been completed and a dynamic, complex, and extensive database has been compiled for testing of the algorithm. The compiled database consists of hourly KSC weather measurements for the past 35 years. Since many real life conditions are described by the variables defined in rough logic, such as weather or launch criteria, rough logic algorithms may be candidates for inclusion mechanisms for making launch decisions.

- Advanced Life Support Automated Robotic Mechanism (ALSARM): Developed the ALSARM which is a three degrees-of -freedom (3DOF) robot that that has been used to automatically collect environmental measurements in the biomedical Biomass Production Chamber (BPC). The system has a sensor package on the end of a retractable arm to record environmental measurements. The ALSARM performs a function normally done manually by biomedical personnel and eliminates the human exposure and contamination resulting from manual measurement recording. The system provides a more

uniform method of data recording allowing for more data to be taken and provides the data in a user-friendly database. A phase II project will be to add a 3DOF end effector (EE) to the robot which can manipulate the plants by taking cuttings and moving these cuttings to the sample airlock. Currently the ALSARM is undergoing subsystem testing in the Advanced Systems Development Laboratory (ASDL). System testing began in April 1997. Integration into the BPC occurred in May 1997. The EE is currently in its preliminary design phase with completion and integration into the ALSARM/BPC scheduled for April 1999. This technology can be optimized to provide an automated plant tending/harvesting system for use in hydroponics modules on Lunar or Mars bases.

HEDS Enterprise Objective 2.5:
Develop opportunities for commerce in space as a basis for future settlements

- The HEDS Enterprise...together with the commercial sector, will examine opportunities for space commerce as well as the full range of capabilities required to support them
- The HEDS Enterprise...will support pilot projects to demonstrate the commercial value of space
- Eliminate barriers to viable space commercialization

HEDS ENTERPRISE GOAL 3
Achieve routine space travel

HEDS Enterprise Objective 3.1:

- Sustain Space Shuttle operations at improved levels of safety and efficiency and improve Space Shuttle safety and develop selected Shuttle performance and capability enhancements
- Meet customer requirements
- Reduce operating cost

KSC Implementation Plans:

- As part of the Shuttle upgrade initiative, lead or participate in the process of identifying and implementing upgrades to the Shuttle systems and ground processing concepts to improve safety, reliability, supportability, and ground operation capabilities and to reduce cycle time. Key areas for improvement include:
    - Replace the LPS with a new CLCS
    - Develop a Vehicle Health Monitoring System Development Test Objective (DTO) in partnership with JSC, leading to a new capability
- As an essential component for safe and economical access to space, support other NASA Center upgrade activities such as:
    - MSFC

    - Propulsion Systems (RSRM, Solid Rocket Booster (SRB), Engines)
    - New liquid flyback booster
  - JSC - Orbiter
    - Fluid/Mechanical Structures
    - Avionics
    - Human Interface/Automation
    - Cockpit Design
- Develop and maintain a critical skill core of project leaders and technical personnel to accomplish and support plans, designs, advanced mission studies, and systems upgrades
- Provide Programmatic Support to Shuttle activities at KSC and manage the program milestone review process, including Flight Readiness Reviews
- Develop and implement advanced instrumentation systems to improve the safety and efficiency of Shuttle and payload processing. For example:
    - Orbiter Automated Window Inspection Device (AWID)
    - LC-39 Ground Measurement System
    - Hazardous Gas Detection System 2000
- Develop and implement Shuttle infrastructure upgrades to reduce processing time, increase safety and reliability, and support the flight rate through the year 2012 and beyond
- Develop the capability and skills needed to conduct increasingly sophisticated levels of research in industrial engineering, process analysis, and applied technology to enhance launch and payload processing
- Work with other Government agencies, contractors, and commercial, industrial, and academic institutional sectors to develop, evaluate, and implement automation intelligent system testbeds to improve operations and reduce costs
- Develop, implement, and commercialize advanced sensors and instrumentation systems for Shuttle and payload processing such as hazardous/toxic gas detection, contamination monitoring, field inspection/nondestructive evaluation (NDE) of in-place flight hardware, intelligent data acquisition, weather/lightning hazard instrumentation systems, optical instrumentation, and intelligent transducers

DE Accomplishments:

- Directly involved in the development of the successor to the current Space Shuttle launch processing system (LPS). The new system is called the Checkout and Launch Control System (CLCS). This system will provide improved flexibility and efficiency by providing the capability to monitor multiple Orbiter testing sites from a single control room. The system is based on commercial off-the-shelf technology and industry standard hardware and software. The distributed nature of the system will increase flexibility and

automation enabling significant reduction in Shuttle operations costs. In March 1997, the CLCS team delivered an experimental control room in

Launch Control Center Firing Room Two, which will allow the customer to participate in the development process. Work is continuing with this effort to incorporate customer inputs into the next release of control room capability scheduled for September 1997.

- Provided support to the CLCS Console Team to address the structural and mechanical aspects of developing the new consoles and racks for the firing/control rooms and other LPS support areas. User requirements for the consoles were developed and design drawings have begun. Spare CORE consoles were obtained and modified at the DTL into Human Computer Interface (HCI) Test-Bed Consoles (early-start consoles). These consoles were then installed into Firing Room 2 for installation of the computer subsystems.

- Developed preliminary concepts for the new Operational Television (OTV) System. The OTV is an important adjunct to verifying launch conditions on the vehicle and its supporting facilities. In addition to a new control system, OTV will interface to the CLCS.

- Java PCGOAL (JGOAL): JGOAL is a software program for display of Space Shuttle and launch systems data in real-time, utilizing a COTS World Wide Web (WWW) browser and the Java programming language. With assistance from Florida Institute of Technology and Princeton University, DE developed a prototype to update the PCGOAL system and extend its useful life. Important features of the new system are:

    - Allows engineers to quickly access needed firing room data from any desktop computer UNIX, PC, or MAC without reconfiguring or running special software.

    - Minimizes travel and other costly delays in the decisionmaking process.

    - Allows engineers to perform a more thorough investigation of Shuttle and payload data in a decreased period of time.

    - Simplifies software configuration management.

    - Reduces network traffic and improves performance.

- Presented two major technology demonstrations of the prototype JGOAL system. On the basis of these demonstrations, the lab has been funded to produce a robust version of JGOAL for use in the CLCS.

- Conducting the thermal and vibration environments analyses required to qualify Development Test Objectives 1 and 2 for flight on the Space Shuttle as part of the Integrated Vehicle Health Monitoring (IVHM) project. IVHM DTO's will assess the technology for permanent installation into the Orbiter fleet.

- Completed a study of the proposed Rockwell and Boeing Liquid Fly-Back Boosters (LFFB) concept. ROM costs for facilities impacted by both the individual and double booster configurations were identified. Current Super Light-Weight Tank (SLWT) excursions and tail service mast (TSM) excursions were provided to Boeing for LFBB configuration analyses.

- Completed an evaluation of impacts to the Space Shuttle umbilical systems due to the new SLWT. DE provided a member to the TSM engineering team, which evaluated three options to address the increased SLWT excursions. Based on the team's recommendation, a Cycle IIA Mod Kit was developed, designed by USA/GSDE, and fabricated at the Launch Equipment Shop (LES). DE provided parts of the Vandenberg Air Force Base (VAFB) TSM links, Environmental Control System Duct Elbows, and a hydrogen flexhose for modification to the new configuration. This enabled the LES to meet the schedule. The TSM engineering team has also developed a plan for a TSM Umbilical Retract Test in the Vehicle Assembly Building (VAB).

- Cable Line Inspection Mechanism (CLIM): Developed a prototype CLIM which is remote controlled, battery-powered tool to inspect the emergency egress and lightning protection cables at the launch pads. This robot will traverse the cables of the emergency egress system and will eliminate the hazardous periodic task of sending inspectors down a basket to inspect the cables. A production version of the system is also planned with the capability to inspect the lightning protection cables. The lightning protection cables are not currently inspected because they are inaccessible. The cable inspection system uses a camcorder and an optical diameter sensor to record defects in cables, as well as provide a radio frequency link to the operator to provide real-time video of the inspection in process. A production version will be developed in FY98.

- Advanced Payload Transfer Guidance System (APTMS): Developing the APTMS which is a smart tool used to assist payload personnel installing payloads in the vertical and horizontal modes. The device measures payload trunnion locations with respect to their respective latches and provides this information to the Move Coordinator on a laptop computer. This data is then used by the Move Coordinator to instruct crane operators how to move the payload to install it in the Orbiter, payload canister, or a workstand. A production unit has been fabricated and tested. After successful testing of the first production unit, additional units will be

fabricated and tested. This tool has the potential to reduce operation time, increase safety, and improve reliability.

- Laser Coordinate Measurement System (CMS): Procured a high-accuracy laser survey tool for robot manipulator calibrations and other high-accuracy measurement tasks. The tool performs dynamic tracking of a target ball and has an accuracy of 0.020 inch over a 100-foot radius. The CMS was used for:

    - Mapping trajectories of the clean access platform in the Payload Changeout Room (PCR) at LC 39-B.

    - Orbiter Maneuvering Subsystem (OMS) Pod/GSE cradle reactive measurement at the Hypergol Maintenance Facility (HMF) in support of a Shuttle mission.

    - Measurements of external tank attachment ring at the booster refurbishment facility.

    - Measurement of payload bay strongback attachment interface holes.

    - Verification of target location for the Automatic Tile Processing Navigation System (ATPS).

    - Alignment of the rack support beams on Space Station Logistics modules mockup installed in the Advanced Systems Development Laboratory.

    - Testing of the advanced payload measurement system.

- Added an electronic gravity level sensor to the CMS. It will be used for the precise installation of payload fitting and other GSE around flight hardware. The following is a list of applications that will be further evaluated during FY98.

        1. Mapping

        2. Workstand Leveling

        3. Alignment of Payload Fittings

        4. Space Vision System (SVS) Target Survey

        5. Dynamic data collection

        6. Holddown Post Bearing Alignment

- Ominbot Mobile Base: Developing a mobile robotic testbed to assess alternate technical approaches for remotely controlled operations in hazardous areas. A prototype base has been designed, fabricated, and tested. Work is continuing on improving its control systems and capabilities. (See appendix A.)

- Tendon Supported Inspections Robot (TENSIR): Developing the TENSIR to make Shuttle Orbiter radiator inspections safer and faster. A spiderlike motion platform with vision systems and sensors is being developed to perform automated radiator inspections. The system will be portable, quick to set-up/take-down, and provide the operator with highly accurate defect position locations.

- Mobile Automated Cleaning System (MACS): Redesigned and installed new circuits in MACS to correct some braking and navigation problems that were intermittently occurring during test runs. The Mobile Automated Cleaning System is a laser-guided, floor-scrubbing robot designed to clean large open areas such as high-bays and airlocks. This battery powered robot can clean a 100 square foot area in 45 minutes, leaving the floor 95 percent dry to the touch. With the minor modifications installed, we began testing MACS in KSC payload processing facilities that have the bar-coded MACS navigation targets installed. These facilities include the Vertical Processing Facility (VPF), the Payload Hazardous Servicing Facility (PHSF), and the Operations & Checkout (O&C) Building High-Bay.

- Launch GN_2 Contingency Advisory System: Provides technical assistance to Ground Systems Pneumatics (GSPN) engineers with contingency planning in the event of a gaseous nitrogen (GN_2) plant failure. GN_2 from the Air Liquide Inc. plant is used extensively at KSC and Cape Canaveral Air Station (CCAS) to support manned and unmanned launches and related tests. A simulation program developed in the Intelligent Systems Lab helps GSPN engineers collect and organize data and perform tedious calculations that would be necessary if the GN_2 plant shutdown. The simulation encompasses a variety of actions to provide continuous support from available GN_2 stored in the various supply pipelines throughout KSC, CCAS, and Complex 39 storage batteries. The program also supports augmentation of stored GN_2 using mobile B.J. Titan rechargers. These calculations are necessary for continuous predictions of support remaining under the various conditions of GN_2 availability and user requirements. Recent features of the program include complete user documentation, automatic input of Air Liquide telemetry data, and a what-if capability to compare duration of support under specified versus current conditions.

- Wireless Operation and Maintenance Instructions: Developed an electronic documentation prototype system which supports online procedure monitoring

and recording by a remote operator for ground processing of the next generation of launch vehicles. The Boeing North American OMS test bed is located in the Launch Equipment Test Facility. The test bed utilizes a pen-based computer supplied by the Intelligent Systems Lab to record measurements and document the development and execution of test procedures. These procedures feature provisions for pen-based field annotation of process steps and automated date and time stamps. Pen-based process documentation is highly portable and easily updated to aid the operator. Electronic documentation promotes safety and efficiency of tests and enhances the accuracy of test data.

- Intelligent Component Expert (ICE): Developing ICE technology, which has been used in high-capability, user-friendly, process monitoring and control systems since 1983. The latest revision of ICE software, ICE-C, has monitored numerous Shuttle LOX loadings for several years. ICE technology was used to study the failure of a fuse in the Mobile Launcher Platform on STS-71. ICE successfully detected the fuse failure when PCGOAL data recorded in 1995 was replayed through the system. The Vehicle Health Monitoring System maintained by Lockheed engineers has incorporated ICE-C, and it has been used during recent flows to monitor the Freon Cooling Loop on the Orbiter during power-up operations in the OPF. Work is underway to demonstrate ICE with the Red Wagon, a LOX loading simulation mock-up.

- Report Log Database/Server: Demonstrated methods to track progress on projects to allow better visibility for customers of DE and management. In addition, developed and demonstrated a method to put all of the archives on-line to allow key word searches of files for relevant past investigations, saving time and costs by eliminating the task of searching personnel filing cabinets for paper versions of the reports.

- Intelligent Fracture Analysis System (IFAS): Developing IFAS, which is a program that will aid personnel in a rapid and complete diagnosis of material failures. Demonstrations were conducted on failure modes of two common varieties of alloy steels. Data was input to the expert system from Southern University case studies and from American Society of Metals (ASM) handbooks. Southern University is assisting Intelligent Systems engineers on the project under a grant from NASA. The system will ask the failure analysis investigator specific questions about the material fracture and present probable causes based on answers and check-boxes entered, and will also be capable of retrieving and presenting similar online failure analysis reports previously filed for component trend analysis or material/environment comparison, etc.

- S9002 Automation Software (S9002): Supported the S9002 Automation Software project. S9002 is a software program for the scheduling and creation of online posttest data review products for the S0007 Operations and Maintenance Instruction (OMI). DE documented user requirements, helped establish a schedule, initiated system design, initiated the software project management plan, designed the database, and conducted extensive research on COTS software and development environments for producing the system. A requirements document for the system was developed and signed off by all interested parties. A joint NASA/contractor software development effort is now underway to create this automated system that will save significant time and effort for Shuttle systems engineers.

- Web-Based System for Tracking Launch Processing System (LPS) Software Changes (USACD): Provided support to the USACD project. USACD is a computer system that will automate Launch Processing System software Configuration Management. The system will support United Space Alliance with reports and status logs on all LPS software changes that are in the engineering or management review process. USACD will reduce paperwork and reduce time spent processing software changes. Intelligent systems engineers have documented extensive details of the process used by USA personnel and are assessing the time and cost savings that will result from implementing the system.

- Neural Networks for Shuttle Diagnostics and Simulation: Developing neural network techniques. Neural networks are a new technique using an abstract approach for simulating and pattern recognition of highly complex physical parameter signatures that may not be related mathematically. Neural Nets may be trained to detect and recognize abnormal behavior embedded within signal signatures which are highly nonlinear and may contain a significant noise component. One of the limitations of simulation and fault detection of Shuttle subsystems is the inherent behavioral complexity of some components during a particular part of an operations process. This behavior usually manifests itself in a highly nonlinear response, which is difficult to model using current analytical techniques. Currently, neural network technology is being applied in the development of S9002 analysis tools to assist the systems engineers in identifying Shuttle problems by providing the following:

    - Improved fault detection and simulation where previously unknown correlations between subsystem components behaviors are now identified.

    - Improved detection quality and analysis time for the Shuttle subsystem engineer where classification of nominal or anomalous conditions can be automatically tagged.

  - Automatic notification of anomalous conditions to CLCS users after integration with S9002 data review room (DRR) project.

  - Neural net can be trained to identify signal signatures as well as identify previously unknown relationships between components or subsystems.

- Payload Inspection and Processing System (PIPS) Serpentine Truss Manipulator: Working on a project to design and demonstrate technologies required for a long reach flexible manipulator to aid in the preflight inspection/verification of payloads in the Launch Pads LC-39A and B Payload Changeout Rooms. A fully functional prototype system was developed and tested in the Advanced Systems Development Laboratory to bring together technologies from other centers, academia, and industry. A unique algorithm was developed by Ohio University for the arm which is called Follow-the-Leader. This algorithm makes the arm move in a serpentine fashion and was demonstrated on a payload mock-up. A sensor skin (developed under an SBIR with Merit Systems) covers the arm and provides for obstacle detection for the full length. The system is still under development with a full demonstration scheduled by the end of 1997. (See appendix A.)

- SRM Stacking Enhancement Tool (SSET): Initiated the SSET project to update and automate the motor assembly process. The Space Shuttle's solid rocket motor (SRM) processing equipment for motor assembly at KSC was designed in the mid 1980's. Consequently, the data acquisition systems and associated processors are becoming outdated, increasingly impacting flight hardware processing and budgets respectively. At the present time, the Space Shuttle solid rocket motors are assembled in the Vehicle Assembly Building on a Mobil Launcher Platform by assembling or "mating" solid rocket motor segments together forming a field joint. Three solid rocket motor field joints are assembled forming the solid rocket booster pressure vessel, with two boosters per vehicle flow. During preparation for and assembly of the field joints, segments shaping, alignment, and assembly "mating" is accomplished. There are three data acquisition systems used during segment assembly operations. The first uses magnetostriction-based linear position sensors and displays the distance to mate, segment rate of engagement, and levelness of the segment during segment assembly. The second is the SRM segment lifting beam load panel, which displays the loads in the motor segment lifting beam drop links and leveling links. The segment lifting beam is used to shape the motor segment by redistributing the loads. The third is the sine bar panel, which measures and calculates the segment shape and is used to recommend lifting beam load distributions utilizing the segment shape prediction program. The current data acquisition systems do not provide a centralized display for the operator. The data displays are

extremely limited in the information they provide and are difficult to read. In addition, not all data is recorded. The SSET project is replacing the existing segment processing data acquisition panels and incorporating the segment shape prediction program onto a single panel providing updated processors and an intuitive "smart" graphical user interface with the capability of recording all data. (See appendix A.)

- Developed the High Efficiency Particle Accumulator (HEPA) Filter Inspection System (HFIS), which is operational and was used for filter inspections in the payload changeout rooms at Launch Complex Pads 39A and 39B. The HFIS is an automated inspection system developed to inspect the HEPA filter banks which are high above the PCR floor and require special hazardous access for inspection. The HFIS is a 4 degree-of-freedom portable robot utilizing the existing 5-ton bridge crane rails for access and has a sensor suite consisting of a particle counter, air velocity meter, laser distance finder, and a video camera to inspect the HEPA filters. Current work on the HFIS includes upgrades to the sensor arm, computer system, and software. The sensor arm, which currently is made from aluminum tubing, is being replaced with an arm constructed of graphite composite. The software currently utilizes LabView and is being upgraded to a Visual Basic application to increase the system maintainability and operator control.

- Upgraded key communications systems and in the process of upgrading others as part of improving Shuttle safety and reducing cost by enhancing communications ground support equipment. Such key systems that have been completed and routinely support Shuttle/payloads checkout, launch, and landing activities include:

    - The Photo Optical Control System (POCS) which provided cost-effective improved operations of engineering analysis photo cameras. The POCS was implemented as a completed project which allows a highly flexible and efficient method of configuring, monitoring, and operating film cameras used for analysis of the vehicle during launches. This system will allow film recording throughout the dynamic range of possible lighting conditions in a manner which increases Shuttle safety and more cost-effective operation.

    - Completed the Paging and Area Warning System (PAWS) in the Launch Control Center (LCC) area which is an integral part of the launch processing communications environment and required to support launch. The new PAWS allows paging messages to be routed to a greater number of areas with a greater selection of specific areas and provides the area warning tones used for personnel and operational safety.

  - Enhanced the Operational Intercommunications System - Digital (OIS-D) by providing a capability to interface to the Paging and Area Warning System and providing increased performance and system reliability. These modifications were essential to ensure a level of support commensurate with Shuttle safety requirements.

- Developing technologies to improve Shuttle safety and efficiency. One such initiative is the Integrated Vehicle Health Monitoring (IVHM) Control System that will provide real-time sensor control, data preprocessing, and data recording during Shuttle flights. DE developed an initial design for an on-board package which will add specialized sensors and record Orbiter instrumentation data. The data collected by the final system will provide comprehensive engineering data, which will be applied to safety monitoring and maintenance. This data will enhance processing efficiency by reducing the amount of data needed to be collected as a part of ground processing. Safety will be enhanced because data will be the result of actual flight conditions, not simulated or static conditions. The IVHM lab was established and is operational. Prototype development hardware is scheduled for delivery to the lab in July 1997 to validate initial design concepts and configurations.

- Plans to develop a unified KSC communications infrastructure which will integrate voice, data, and video into a highly reliable network capable of supporting all Shuttle/payloads needs and future vehicles launch and processing requirements. Such a system will be able to accommodate all requirements from critical to administrative in nature, while increasing efficiency, safety, and security.

- Supported the design and implementation of Communications Systems required in CoF projects. This included providing technical assistance and direction, including producing the communications premise wiring system drawings, for the following facilities: HMF Control Room, LC-39 Outpost Observation Post, Payload Ground Operations Contractor (PGOC) Maintenance Facility, component refurbishment chemical analysis (CRCA) Phase II/Chemical Analysis Facility, and Firing Room 4 {CLCS Operational Control Room (OCR)}. Also, during this time accomplishments include the review and approval of shop drawings and/or the support of activation testing of the following facility communications systems: the Space Shuttle Main Engine (SSME) Processing Facility, CRCA Phase II/Chemical Analysis Facility, and CRCA Phases I/Component Refurbishment Facility.

- Served as technical contact for the design and installation of pneumatic and hydraulic systems in the CRCA facility. Construction of the CRCA facility is being accomplished in two phases. Construction of the Phase I part of the facility, which consists mainly of a utility annex, a clean room (with one flow

test cell, one cryogenic test cell, and four high pressure test cells), an aqueous clean lab, a component disassembly area, a rough clean area, a hydraulics lab, and a shipping/receiving area was completed in early 1997. Pneumatic systems in these areas include gaseous nitrogen at 14000 psi, 10000 psi, 6000 psi, and 100 psi; gaseous helium at 14000 psi and 5500 psi; breathing air at 3900 psi; and gaseous oxygen at 2200 psi. Interior high pressure pneumatic panels and consoles for the facility were designed with USA, procured by USA, and will be installed in the facility in mid 1997. Construction of the Phase II part of the CRCA facility, which will consist mainly of chemical analysis labs and field cleaning and decontamination areas, began in June 1996. Pneumatic systems in the Phase II areas will include facility GN_2, gaseous helium (GHe), and breathing air as well as various span and zero gases supplied by K-bottle and regulated to 100 psi via small regulation panels. When complete, the CRCA facility will have the capability to perform the same functions that are currently performed at the existing Wiltech facility, including refurbishment of components and analysis of chemical compositions. The new facility, however, will have provisions for aqueous cleaning equipment to replace cleaning equipment currently using CFC's.

- Managed the design effort to replace the heating, ventilating, and air conditioning (HVAC) and chilled water piping systems on the three MLP's. A feasibility study on changing the chilled water system to an air-ducted and the 100 percent design package were completed by Reynolds, Smith & Hill, Inc. (RS&H).

- Continued to serve as lead for the controls and instrumentation of the liquid helium (LHe) supply system at the Converter Compressor Facility (CCF) project. The electrical design, which was included in the construction engineering design package, was completed and contracts were awarded in February 1997. The contracts include a 30,000-gallon LHe storage dewar, four GHe compressors, two surge vessels, a helium vaporizer, pneumatic panels, vacuum-jacketed flexhoses, and facility modifications. DE continues to support contractor site visits to assess contractor progress and performance. The control system hardware was received in May 1997 and will be turned over to the contractor for installation. At the present time, software programs are being written to monitor and control the system. The project is scheduled for completion in April 1998.

- Preserved KSC operational radio frequency (RF) lines of sight clearances by participating in coordination and analysis activities together with GSFC. Activities included coordinating the location of new electrical power poles installed along the NASA causeway with Florida Power and Light. Also assessed a request for issuance clearance for a Spaceport USA tour stop close to LC 39 Pad A. At issue was how to best avoid blockage or reflective interference of the RF lines of sight between the Merritt Island Launch Area

(MILA) Space Tracking and Data Network (STDN) tracking station and LC 39 Pads A and B. Also provided guidance to the CCAS Johnson Controls Facilities Planning office in the preliminary site planning for proposed new facilities at CCAS Launch Complexes.

- Improved the operations of the KSC RF Communications System by developing systems to monitor and display activities of the KSC radio nets in real-time. This improves the response time of Operations and Maintenance functions. Continued collection of data on the two-way radio system channel activity, using a computerized surveillance receiver system. Statistical analysis of this data is performed to show loading of the system during critical periods.

- Continue to develop an implementation plan for the installation of a modern trunked two-way radio system at KSC. Procured samples of modern base station equipment to evaluate its use as replacements for equipment on nets that would not be included in a modern trunked system, such as crane operations.

- Pursued advanced development and general support for Voice Communications Systems. Began testing and evaluating advanced methods of voice communications over local area networks at KSC. Work to set up laboratory space and procurement of equipment for the test bed is underway. Research into various digital audio interfaces platforms has started to provide a basis for familiarization, demonstration, and test capability.

- Developed algorithms and field tester for use with a Digital Signal Processor (DSP) to recover speech from audio channels originating in high noise environments.

- Improved the efficiency of KSC voice, video, and data distribution and transmission systems. Systems and projects that benefited include the KSC Wideband Fiber Optic Transmission System, Payload and ISS high speed routing and switching systems, and the KSC Fiber Distributed Data Interface (FDDI) Transmission System (FTXS). Some of the specific accomplishments include:

    - Procured and completed acceptance testing of new hubs for the FTXS. The new hubs will reduce the number of archive hubs required, replace obsolete hardware, and eliminate most system single failure points.

    - Completed installation and checkout of the Industrial Area portion of the Remote Monitor and Alarm System (RMAS). The RMAS improves operations and maintenance efficiency by providing centralized realtime remote monitoring of the health and status of KSC Wideband

Fiber Optic Transmission System equipment located in facilities across KSC. The equipment monitored includes fiber optic transmitters and receivers, frequency division multiplexers and demultiplexers, and T-carrier multiplexers and demultiplexers.

- Completed KSC Communications Systems Upgrade Preliminary Engineering Report. This document develops a preliminary design for a network at KSC that consolidates many of the existing networks and uses Asynchronous Transfer Mode (ATM) switching with a Synchronous Optical Network (SONET) physical transport layer. The requirements for a network upgrade were derived by examining existing KSC transmission systems and identifying systems for partial or full network consolidation. The resulting design proposes an ATM over SONET metropolitan area network which supports combined voice, video, and data traffic for the facilities at KSC.

- Completed the ATM Backbone Switch Specification for use by the KSC Communications Systems Upgrade project. This specification establishes the minimum functional requirements, on-site technical services, and sustaining support. This document also provides the functional specifications for the ATM backbone switch and outlines the acceptance criteria.

- Selected and procured three ATM backbone switches and ATM test equipment for use in the KSC Communications Systems Upgrade project. The procurements were completed and units are being tested in the lab. These ATM switches will also be used to test the CLCS/LON link to the HMF using the ATM Lab facilities.

- The ATM Pilot Network was made operational and is being used to test ATM backbone switches and facility switches.

- Updated the fiber optic cable specification developed for KSC fiber optic cable procurements to include temperature cycling tests found to be required during laboratory analysis of the failing Phase IX cable. Provided technical input to the USA contractor during the procurement of the replacement cable.

- Pursed KSC digital video transmission and desktop video baseline development activities. Some of the specific accomplishments include: (1) research of MPEG-2 compression for transmission of digital video at KSC; (2) procurement of digital video conversion and test equipment; and (3) procurement of fiber optic digital video transmission equipment.

- Continued supporting the upgrade of the LC-39 area facilities OTV system, which will improve operational efficiency, safety, and future vehicle support.

    - Supported initial planning for providing digital video routing and switching capability in the LC-39 Launch Control Center.

    - Completed a prototype of a fiber optic direct link for the video and control signals to a TV camera, and transferred some of the key attributes of the prototype to the OTV upgrade project.

    - Designed a prototype user interface for the LC-39 OTV Tracker Control System.

- Continued upgrading the Payloads Facilities Closed Circuit Television (CCTV) Systems that support payloads processing in Industrial Area payload facilities.

    - Identified and resolved payload facilities camera/pan tilt unit vendor Control software anomalies.

    - Completed the facility CCTV systems upgrade and turnover for Spacecraft Assembly and Encapsulation Facility (SAEF) II.

    - Began design of the facility upgrade for the VPF CCTV system. Completed contract with the camera/pan tilt unit vendor for 10 additional payload facility cameras and pan/tilt assemblies (SAEF II and VPF).

    - Identified modifications required for the SSPF camera control system to handle planned payload CCTV requirements. Initiated contract modification with the vendor to upgrade SSPF camera control software. Identified need for SSPF switcher expansion and completed cost estimates to accomplish the task.

- Prepared and submitted new and updated KSC Center digital television (DTV) conversion budget. Prepared pitch for NASA High Definition Television (HDTV) Working Group regarding the impact of the new FCC digital television standard to NASA and KSC.

- Led and/or made significant contributions to KSC and NASA communications related committees, councils, teams, and working groups. Chaired the KSC Communications Steering Group and the KSC Internet Network Working Group (INWG). DE was actively involved in the NASA Security Working Group. DE was also actively involved in the development of the NASA Strategy for Windows-NT Domains, the Intranet Requirements Document,

the Intranet Strategy Document, the NASA Directory Services Architecture, Standards and Products, and the NASA Firewall Policy.

- Developed a document to be used in selecting cost effective and available service alternatives to the existing Kennedy Switched Data Network (KSDN). Deactivating the KSDN will allow Shuttle organizations to realize significant operational cost savings through the elimination of redundant means of data access and retrieval.

- Performed design, component selection, and developed an installation package to upgrade the performance, capacity, and latency characteristics of the network servicing the Reliability & Quality Directorate. This upgraded network is required to provide NASA-wide access to the Fast Retrieval Enterprise Data (FRED) System, which is a data warehouse for Shuttle Problem Reporting and Corrective Action (PRACA) databases. This network also provides service for the Interactive Web based Training system, which is intended to reduce the associated training costs.

- Significant accomplishments in KSC Firewall development include:

    - Developed a working KSC WAN Interface Security Gateway Prototype. The Wide Area Network Security Gateway (WSG) was developed to address the router shortcomings, that is, relieve the router from the filtering burden, and provide extensive logging capability. The Security Gateway was built under the Microsoft Windows NT 3.51 operating system, an operating system NASA has accepted as a server-based platform for general computing. The basic philosophy of the Gateway design is simple: filter the packets entering and leaving KSC networks and log the transactions. The Security Gateway Prototype is currently undergoing testing.

    - The WAN Interface Security Gateway Prototype has been running in parallel with the KSC Isolation Router (ISO) router for 6 weeks without problems. The Security Gateway is running in worst-case mode collecting all data and sending back to the database. The Gateway is being ported to Windows NT 4.0 and is expected to play a major role as part of KSC Firewall development.

- Updated the Kennedy Space Center Network Handbook. This includes reformatting the document, replacing the contents with the latest KSC network information, and revising the drawings to reflect current KSC network configurations.

- Completed several improvements for the DE developed Network Documentation System (NDS). NDS was designed to standardize and consolidate documentation entry and recall for DE, Shuttle, payloads, and ISS communications networks at KSC. It provides a means for network tracking, configuration, and control. The NDS computerized database allows users easy access to network information and has shortened response time for identifying and solving network problems.

- Developed Automated Test Equipment (ATE) to certify multiple Universal Signal Conditioning Amplifiers (USCA's). The ATE will validate proper operation of USCA's before they are used to support instrumentation for the Launch Complex 39 Permanent Measurement System (PMS). The ATE currently is in its final phase of testing and is scheduled for delivery at the end of July 1997. DE continues to provide classroom and hands-on training to operation personnel on the use of the ATE.

- Developed advanced cryogenic and hypergolic hazardous gas and fire detection systems to maintain and improve levels of safety in ground, launch, and landing operations.

- Developed advanced field inspection instrumentation to more efficiently inspect Orbiter windows for micro-meteoroid impact damage, Orbiter and ET insulation debonds, corrosion beneath painted surfaces, surface defects on critical mating surfaces, and Orbiter radiator panels.

- Developed low-cost/high-accuracy optical and acoustic systems to guide the assembly and mating of SRB, external tank, Orbiter, and payload flight hardware.

- Developed, standardized, and validated transducers, signal conditioning, data acquisition and control systems for KSC launch, landing, and payloads checkout systems and facilities.

- Developed real-time contamination monitors to protect payloads and flight hardware from aerosols, particle fallout, nonvolatile residue, hydrocarbons, etc.

- Developed state-of-the-art gas detection systems for use in enhancing Shuttle safety, improving processing times, and reducing operating costs. The Portable Aft Mass Spectrometer (PAMS) system is used during the V-1202 Aft Fuselage MPS end-to-end helium signature leak test. Use of the PAMS precludes exposing the Hazardous Gas Detection System ion pump to air during V-1202, with subsequent failure and expensive replacement.

- Developed advanced ultrasonic leak detection and location device for use in finding leaks at SRB field joints. This hardware is ten times more sensitive

than commercially available devices. Also, it is being considered for adaptation to use on ISS.

- Developed external tank centering and alignment hardware to facilitate centering of the ET between the SRB's. This enhances safety by eliminating the need to suspend a man in a sling for the alignment operation.

- Developed improved dimethylethoxysilane (DMES) monitors to protect personnel and ensure maximum efficiency in Shuttle processing in the OPF's.

- Developed improved oxidizer scrubber liquor to reduce atmospheric emissions and to eliminate second largest hazardous waste stream at KSC.

- Developed automated hypergol calibration system to process new 10-ppb instruments directed for use at KSC.

- Initiated studies on methods to prevent or at least reduce the effects of corrosion of rebar in concrete structures in order to extend the useful life of all structures at KSC.

- Continued research into alternate cleaning processes in order to reduce or eliminate use of chlorofluorocarbon (CFC) based cleaners.

- Leading the efforts to upgrade the ground measurement system (GMS) which will replace the Permanent Measurement System at both LC-39 pads and all three Mobile Launcher Platforms. The upgrade will utilize several products that were developed from dual use commercialization projects. Pad A will be completed in FY97.

- MSBLS Flight Inspection System: Developed the real-time MSBLS flight inspection and certification system based on industry standard VXI UNIX workstations. Software for this system was written in UNIX-based X-Windows "C" language. This system has reduced the flight-test certification duration from 6 weeks per site to just 4 hours.

- MSBLS Near Field Calibration System: Developed the mobile/tower-based MSBLS calibration system. The system will reduce calibration time and cost for the Transatlantic Abort Landing (TAL) sites by doing the work on the ground without utilizing an aircraft.

- Upgraded the LC-39 meteorological system with a new design and installed it at each pad with the central station located in the LCC. The system eliminated long run analog lines by digitizing the signals at each meteorological site and thus improved the accuracy of the system. The upgrade also replaced the old strip chart with state-of-the-art data displays.

- Designed a series of devices for recording electric and magnetic fields generated by lightning strikes. These devices are basically battery powered transient recorders which can be placed at the pads for recording field strengths to determine if the field strengths generated by pad lightning strikes could have damaged payloads in the PCR or in the Shuttle.

- Developed a hydrogen fire detector that will not alarm to false signals created by ultraviolet (UV) reflections. The existing fire detectors at the LC-39 pads are very prone to false alarms from the hydrogen flare stack reflections. The new fire detector utilizes state-of-the-art technology to determine if the UV being detected is truly from a hydrogen fire or is just a reflection.

- Developed a nonintrusive cable tester to find shorts or opens in cables located in the instrumentation systems on board the Shuttle without having to disconnect cables. Existing instrumentation is unable to meet the restrictions and system limitations for the onboard systems. The developed unit will improve the efficiency of troubleshooting efforts.

- Performed qualification and compliance testing of platinum resistance temperature probes and signal conditioners used in SRB heater, liquid oxygen and hydrogen line, and emergency egress temperature measurements, as well as for other miscellaneous launch pad temperature measurements.

- Performed qualification and compliance testing of a wide range of pressure transducers, used extensively within the launch pad and Orbiter processing areas. Pressures are used in a multitude of applications, including external tank heated purge system, miscellaneous gaseous nitrogen purge system, and hydraulic systems monitoring.

- Performed qualification and compliance testing of H_2 leak and flame detectors used for processing, prelaunch flow, and Space Shuttle launch sequences.

- Performed qualification and testing of strain gage signal conditioners utilized within Orbiter processing facilities, the Hypergol Maintenance Facility, and the Space Shuttle launch complexes, in conjunction with strain gage pressure transducers, load cells, and direct strain measurements.

- Performed design, fabrication, testing, and implementation of UV flame detector calibrators for laboratory calibration of KSC's UV flame detector.

- Performed design, fabrication, testing and implementation of multifunction, handheld UV sources for field validation of UV flame detectors.

- Performed prototyping and testing of DMES filters for hydrogen (H_2) leak detectors utilized in the OPF's to eliminate premature aging of H_2 sensor beads during Orbiter processing.

- Performed vibration testing of launch pad Remote H_2 sensing cabinets to minimize component mechanical damage due to extended cabinet operations and launch environments.

- Developed and maintain the KSC transducer specification to ensure compatibility and consistency among KSC utilized transducers.

- Supported Shuttle Operations by performing reviews, consultations, and evaluations of current systems, as well as new Shuttle-related projects.

- Found a suitable replacement for the MLP-1 TSM 1-½-inch Hydrogen High-Point Bleed Lower Flexhose, which failed due to loss of vacuum. A VAFB flexhose was located, evaluated, and shipped to NASA operations for substitution. Drawings and key dimensions were also provided.

- Evaluated a request by MSFC to instrument the gaseous hydrogen (GH_2) Vent Umbilical Pyro Bolt, which operates under a reduced factor of safety of 1.3 in a permanent ICD change. Evaluated this request in support of NASA Operations and determined that based on previous USA/GSDE analysis, flight readiness firing (FRF) data/analysis, and the unlikely event of excessive winds occurring during launch due to return to launch site (RTLS) constraints, the instrumentation was not required because the factor of safety would not decrease below 1.3.

- Assessed the factor of safety of the gaseous oxygen (GOX) vent umbilical, which had been operating under a temporary waiver against the 2:1 factor of safety that expired after STS-80. DE evaluated previous launch data, including during STS-59 in which an axial adjuster had broken, and determined that the STS-59 damage occurred due to random launch conditions resulting in a superposition of three harmonic vibrations. After evaluation of modification options for increasing the factor of safety to 2:1, recommended that a permanent waiver be approved, with loads being monitored during launch. If loads were excessive, an inspection of critical parts for yielding would occur.

- Provided support and evaluation of a proposed new laser alignment system for the GOX Vent Umbilical, developed by NASA Operations, NASA DE, and I-NET, eliminating both the painting of an alignment grid on the external tank and the use of light sticks.

- Reviewed a safety board accident report on the B-1 Test Stand Hydrogen Vent Line Failure at Stennis Space Center (SSC) and provided additional comments.

- Reviewed the NASA-wide safety document NSS 1740, “Safety Standard for Hydrogen and Hydrogen Systems,” in support of NASA Safety at KSC.

- Serves as a technical contact to the Pressure Vessel/System Manager for pressure vessel/system certification issues at KSC. Responsible for certification packages in accordance with KHB 1710.2 on pneumatic and hydraulic systems in the Launch Equipment Test Facility and Development Test Laboratory areas.

- Serves in the KSC Materials and Processes Working Group.

- Supported the Agencywide evaluation of CAD/CAE/CAM activities by hosting NASA Headquarters and Lewis Research Center (LeRC) representatives and providing Microstation drawings and ProEngineer 3D solid models. Also chartered the ProEngineer working group, which provides a forum for standardizing ProEngineer to KSC formats and drawing requirements.

- Provides Shuttle launch support during propellant loading operations and liftoff.

- Provides design, testing, and procurement support to other NASA/KSC and contractor organizations.

- Conducts ongoing test programs at the Launch Equipment Test Facility for the Shuttle Holddown Post Calibration and the solid rocket motor (SRM) lifting hardware.

- Provided the design of SSME Scissor Lift Tables for use in the new SSME engine shop. The tables will provide personnel access to the engine nozzles for inspection and repair work.

- Worked with NASA payloads on a study of new payload transporters. Specifications for refurbishment of the existing transporters as well as for procurement of new transporters were completed. A lease/maintenance option is currently under evaluation.

- Provided support to USA in procurement of a 3-micron final filter for the Orbiter and SRB hydraulic systems. The qualification testing was monitored, and an independent laboratory was utilized to validate the test results. Testing was completed in April 1997 with procurement to follow.

- Supported the Space Shuttle System Loads and Dynamics Panel.

- Provided vibration specifications for the design of the new pad elevator controllers to ensure their launch environment survivability.

- Provided vibration specifications for the new Mobile Launcher Platform heating ventilation and air conditioning systems to ensure their launch environment survivability.

HEDS Enterprise Objective 3.2:
Ensure the health, safety, and performance of space flight crews through space and environmental medicine

- Refine and improve crew health requirements for support of humans in space flight
- Determine requirements and conduct technology demonstration projects to guide the development of crew systems on future space transportation systems

KSC Future Plans

- Support JSC in the development of cutting-edge life support technologies

DE Accomplishments:

- Provides support to the Advanced Life Support (ALS) Breadboard project by designing and producing hardware that is used in plant growing applications and experiments in the KSC Biomass Production Chamber. DE fabricated two Clinostats (a test bed for environmental controls, instrumentation, and software development to be used for studies in plant nutrition and microbial ecology), a thermal gradient seed fixture, inserts for hydrophonic trays, and heat exchanger coils. This project conducts experiments to determine the most suitable alternatives for plant growing and waste management during extended space flights (for example, to Mars).

HEDS Enterprise Objective 3.3:
Develop requirements and demonstrate and implement advanced propulsion systems and other advanced space transportation systems and capabilities to enable exploration

- Establish Agency leadership to focus advanced propulsion activities to meet long-term exploration goals
- Explore revolutionary space transportation systems and technologies to improve capabilities and radically reduce the cost of human space flight
- Work with...(Aeronautics and Space Transportation Technology) to demonstrate technology required to enable the development of low-cost,

reusable launch vehicles as a means for potentially significant reductions in the cost of access to space

KSC Implementation Plans:

- Utilize KSC's background and experience to support the design and development of new space vehicles, ground systems, logistics, and facilities
- Continue to support X-generation launch vehicle development
- Continue development of advanced hazardous gas and flame detection systems and sensors to support ground testing, launch checkout, and flight operations of advanced propulsion systems
- Continue to provide field support instrumentation and expertise to other NASA Centers and contractors
- Support liquid fly-back booster and nonhypergolic Orbiter Maneuvering Subsystem development

KSC Future Plans:

- Provide technical expertise in fluids manufacture, production, transportation, storage, chemical characterization, and distribution and in systems for launch and payload processing to the Lead Center in support of the NASA advanced propulsion initiative
- Provide facilities and experience to assist in the development of launch facilities and systems for future commercially developed space vehicles and payloads
    - Assist the Agency by providing KSC as an operational testbed through use of KSC-unique test facilities and laboratories
    - Provide vehicle processing, payload processing, process analysis, ground systems development, safety requirements and policy, and logistics support expertise
- Support Spaceport Florida Authority to develop facilities for future launch vehicles and programs which will enhance the ability of KSC to support such programs
- Support the definition and new requirements delineation for new space flight vehicles

DE Accomplishments

- Via a Task Agreement with the Lockheed Martin (X-33 contractor), developed a Ground Interface Module used for data acquisition for the Launch and Mission Command and Monitor System in the X-33 Project Operations Control Center. The GIM completed verification and acceptance testing at KSC in June 1997. Units will be sent to various Lockheed Martin sites for integration with their systems over the remainder of 1997. DE personnel will be going to GIM delivery sites to support integration activities and provide

hands-on operational and orientation training to the Lockheed Martin personnel who will be performing X-33 checkout and launch.

- Provided design and analysis for umbilical systems and facilities in support of the X-33 Advanced Technology Demonstrator. (See HEDS 1.1)

- Provided evaluations and design concepts for the Evolved Expendable Launch Vehicle Program. (See HEDS 1.1)

- Completed a study of proposed Liquid Flyback Booster concepts. (See HEDS 3.2)
- Completed an evaluation of Super Light-Weight Tank impacts to Shuttle umbilical systems. (See HEDS 3.2)

- Hosted NASA-JSC and Boeing representatives from White Sands Test Facility in support of umbilical design for the Bantam Booster. The Bantam Booster is being developed by MSFC as part of the Low Cost Booster Technology Development Program and the Advanced Space Transportation Program (ASTP). DE provided consultation and tours of the Shuttle and Expendable Launch Vehicle systems.

- Designed and fabricated a new rise-off umbilical that will have potential applications for future launch vehicles, including X-33 and the Evolved Expendable Launch Vehicle (EELV). The system is a ½-scale working model and includes cryogenic, pneumatic, and electrical connectors. The umbilical is a fully passive system and serves as a proof-of-concept for rise-off umbilical-type systems. The test fixture design, fabrication, and assembly, ground and flight carrier plate fabrication, and initial testing of the mating sequence were completed in March 1997. Incorporated in the rise-off umbilical demonstration system will be a custom Taper-Lok pressure-energized sealing connector. The standard Taper-Lok connector was successfully bench tested at both liquid nitrogen (LN_2) and LH_2 temperatures in December 1996. The connector was loaded to 1,640 pounds (total) using individually calibrated Belleville spring stack assemblies.

- Prepared and submitted propellant loading systems concepts for liquid oxygen and RP1 and cost estimates for X-34 in June 1996.

- Supported Phase I testing of the liquid hydrogen densification unit at NASA LeRC/Plumbrook in December 1996 as a part of the Propellant Densification Technology Demonstration.

HEDS ENTERPRISE GOAL 4
Enrich life on Earth through people living and working in space

HEDS Enterprise Objective 4.1:
Promote knowledge and technologies that promise to enhance our health and quality of life

- Disseminate scientific, medical, and technological information
- Continue to pursue an active program of technology transfer
- Undertake joint venture in partnership with our key customers and suppliers
- Define concept and develop technologies to enable earthly benefits from space resources and the promise of in-space commerce

KSC Implementation Plans:

- Expand the existing KSC educational outreach program
- Develop a more effective method to portray and disseminate benefits of NASA technology to the general public
- Expand cooperative agreements with Federal, State, and local environmental agencies to share environmental management information
- Expand KSC technology programs and commercialization in the following areas:
    - Dual-use technology development partnerships
    - Technology transfer/commercialization outreach with State of Florida and the U.S. Southeast region
    - Technology outreach and business incubation with Florida's minority universities

KSC Future Plans:

- As the focal point for applied research, KSC will work as a team member with the Agency, industry, and academia to transfer and apply NASA-developed technology at KSC, within NASA, and to commercial applications
- Disseminate information on advanced technological efforts in environmental remediation, habitat modeling, and ground water modeling

DE Accomplishments:

- Continued leadership in technology transfer by commercialization of Instrumentation Development Labs technology such as Universal Signal Conditioning Amplifier/Advanced Data Acquisition system, UV/IR Hydrogen Flame Detector and calibrators, particle fallout monitors, Fourier Transform Infrared (FTIR) spectrometer software, and dual-phase flowmeter. DE continued to support all aspects of the Technology Transfer program, including joint use partnerships, industry outreach, patents and licensing, space act agreements, and SBIR grants.

- Began setting up a potential dual-use project for a helium cold gas compression (CGC) system. The goal of the project is to design, build, and demonstrate a CGC system that accepts liquid helium and produces up to 1,200 standard cubic feet per minute (scfm) helium gas at 6,000 pounds per square inch gage (psig). This system would have three main advantages: high pressure/high quantity delivery; low power consumption; and higher reliability (i.e., lower maintenance). This system would have wide-spread NASA and Department of Defense (DOD) applications. The CGC method is much more applicable to the design of portable, high-reliability helium charging systems. The Research Triangle Institute (RTI) is performing a detailed market survey for possible industrial partners.

- Developing a 2-Phase Quality/Flow Meter in a dual-use partnership with Air Products. Air Products is projecting the market to request hundreds of these meters. The meters are expected to be available for market in early 1998. Steam/air and waste water applications are under investigation.

- Designed and fabricated 16 carbon dioxide (CO_2) chambers at a remote site at KSC in conjunction with the Department of Energy and the Smithsonian Institution. These sites will be used by scientists throughout the world to measure elevated CO_2 concentrations on Florida vegetation, which will help determine the impact that the “greenhouse effect” will have on Earth.

- In support of the primary KSC mission, Space Launch, and our designation as NASA Center of Excellence for Launch and Payload Processing Systems, KSC maintains unique laboratories, facilities, and engineering expertise required to perform our day-to-day tasks of processing payloads, launching expendable space vehicles, and launching human-tended space vehicles. The Technology Programs and Commercialization manages and coordinates KSC’s technology development and transfer programs which support this primary mission and associated HEDS activities. Our accomplishments in this regard include:

    - Five new patents were filed and three new patents were issued for KSC technologies.
    - Two KSC patented technologies were licensed by commercial partners bringing the total of active licenses to eight.
    - Four new partnership agreements were signed with commercial organizations for joint NASA/Commercial development of mission required technologies.
    - Two hundred eleven cash Space Act awards were issued to KSC innovators for their support in developing and commercializing new technologies.
    - Eleven targeted trade shows were supported to promote new agreements for commercialization of KSC technologies.

    - Five TV or radio shows were supported to promote knowledge of the commercial and civil benefits of NASA-derived technologies.
    - Speeches were presented to 44 civic or business groups within Florida to promote knowledge of NASA programs and the resultant benefits of supporting KSC technologies.
- The Florida/NASA Business Incubation Center supported seven resident tenants and twelve off-site tenants. One tenant graduated during the period.
- The KSC Commercialization home page was accessed an average of 100,000 times a month. Approximately 2800 Technical Support packages were sent in response to electronic requests for information about KSC technologies.
- Administered the KSC portion of the Small Business Innovative Research program and evaluated the commercial potential for 22 Small Business Innovation Research projects which resulted in award of over $5.7 million to small businesses supporting KSC mission needs.
- Evaluated 18 unsolicited proposals and facilitated award of $840,000 in research grants for 12 projects supporting KSC mission needs.
- Initiated a program to promote KSC as a testbed for NASA-wide technology development.
- Initiated a program to increase the use of KSC facilities and expertise in support of other centers, other agencies, and commercial organizations on a reimbursable and space-available, noninterference basis.
- Supported the Administration Office with its initiation of a new partnership with minority universities to provide commercialization experience.
- Initiated an independent study to evaluate potential for success of new business incubation centers within Florida.
- Over 300 requests for technical assistance were processed through the Technology Outreach program.

    - An automotive transmission manufacturing company requested help cleaning assembled automatic transmissions after testing. DE provided advise on environmentally friendly methods to clean the transmission cases and valve bodies.

    - A company that manufactures piston engines for commercial and military aircraft encountered a problem with its crankshafts. The crankshafts were cracking prematurely. We Investigated the stress and metal fatigue of the design and recommended changes to the material and processing which allowed the crankshafts to exceed their design life and satisfy all Federal Aviation Administration (FAA) and military requirements.

    - An independent inventor devised a novel jack to lift a boat trailer. He did not know how to determine its safe load capacity. DE analyzed his

design and made material and design recommendations which allowed his jack to satisfy the needs of the intended application.

- To reduce aircraft wheel wear during landing, a Florida company devised an aerodynamic method to spin the wheels up to landing speed. The company requested assistance in sizing the air pockets which were added on the sides of the wheel. Provided an aerodynamic analysis of the wheel pockets to determine how effective they would be and also researched tire wear to determine how much they would help prevent damage.

- A company that manufactures tools for electric utility servicing wanted to make its connector tool lighter and cheaper. The tool was made as a high-strength steel forging. They wanted to make a casting to save money and to investigate using aluminum as the material. Analyzed the tool for stress, wear, and fatigue. DE's design suggestions and data allowed the company to reduce costs by half. Aluminum could not satisfy the performance requirements.

- Fatigue cracks caused the premature failure of automotive air-conditioning compressors. The rotors failed at a fraction of their design life. The manufacturer was about to go into full production when the problem was discovered. Analyzed the stresses in the rotor and suggested a repair procedure for the existing rotors. In addition, suggested a design change which eliminated the problem in future rotors and reduced weight and cost significantly.

- A new diesel fuel injector design was developed by a Florida company for ships and locomotive applications. The company did not have the expertise to check the design for stress, wear, and fatigue and we have provided that effort. The injector stresses were too high so a design change was suggested to allow the injector to satisfy the load and life cycle requirements.

- A glider manufacturer requested help to improve its ultralight strobe circuit design. A minor change to reduce the maximum current draw was recommended to decrease the product's failure rate. Another design was also considered for potential future use.

- An air-bag manufacturer requested help to improve its air-bag bushing design and inspection. An inspection device was recommended to verify the diameter of the bushings after molding.

- A dog training company requested help on the release and control of dogs during training from a distance. A scheme for remotely releasing

the dog was recommended to the company, which is implementing the suggestion.

- A shoe manufacturer requested help on automation techniques for applying adhesives to bond shoe assemblies. Help was also requested on software approaches to the automation of shoe construction and applying thermal adhesives in the assembly process. Technical recommendations were made to the requester concerning these problems.

- A printing company requested help in improving its methods of locating labels and graph printing tolerances. Methods were recommended for measuring devices which would improve speed and reliability in these processes.

- A paper cup manufacturer requested help in devising a way to orient paper cups prior to labeling so lap joint does not interfere. Recommendations were made to orient the cups prior to printing.

- A company packaging disposable utensils requested help on a pick-and-place device to assemble utensils into a package. Recommendations on methods of assembling the items were provided to the requester.

- Demonstrated and provided information to a major chemical company on the use of the DE-developed Supersonic Gas-Liquid Cleaning System (SSGLCS). The SSGLCS was used to clean laser printer Organic Photo Conducting (OPC) rolls that need to be precision cleaned prior to coating with an electrostatic compound.

- Demonstrated the use of the SSGLCS to clean carbon brake dust off of Airbus A300 wheel halves.

- Performed a deflection analysis on the deflection of a support beam for an architectural window coverings firm. Gave design recommendations for proper beam sizing based on variable material and geometric parameters.

- Additional Technology Transfer Agreements completed during this time include:
  - High-Speed Door Breakaway Bottom Rail (Chase Dures, Inc. Cincinnati, OH)
  - Knots and Shives Drying Pine (Agri-Product Special Markets, Inc., Tallahassee, FL)
  - Argon Gas Pressure Verification (Raytheon Company, Tewksbury, MA)

- Analysis of Pressure Vessel Design (Lubriclave, Inc., Ft. Lauderdale, FL)
- Screw That Feeds a Pelletizer Plastic Machine (Recyplast, Port Canaveral, FL)
- Wearstrip Mobility (Conveyer Systems, Inc., Sanford, FL)
- Seal Leakage Problem in an Electro Magnetic Device (Electro-Mag Industries Corporation)
- Wear of Mechanical Sensor/Design of Return Spring (American Bolting Technologies)
- Skin Effect Heating (PHPK Technologies, Inc.)

HEDS Enterprise Objective 4.2:
Broaden and strengthen our Nation's achievements in science, mathematics, and engineering

- Provide instructional materials reflecting the discoveries and adventure inherent in space exploration in support of curriculum standards
- Form partnerships with educators to bring space exploration experience into the classroom

KSC Implementation Plans:

- Continue our partnerships with schools (elementary through college)
- Expand and improve summer faculty development program
- Continue to make available KSC-unique expertise to local school systems through personnel appearances, science fair judges, and mentor programs

DE Accomplishments:

- Provided mentors for the Virtual Science Mentor Program. This program will provide Internet-based video conferencing equipment to the participants and will require 1 hour per week during the 1997-1998 academic year. During this hour, the engineers will have a PC-based video conference with the middle school class located in a geographically distant part of Florida and act as mentors on science subjects.

- Provides technicians to demonstrate robotic technology to many Florida high schools.

- A number of university professors were employed in the DE laboratories last summer to work with engineers infusing new technologies and sharing ideas for new technology development:

    - Dr. Paul Lien Wang of the University of North Carolina at Charlotte worked on two hydrogen vent line explosions at Stennis Space Center Space Shuttle Main Engine tests stands.

- Dr. Rodney Roberts of Florida A&M University (FAMU)/Florida State University (FSU) worked on the accuracy tolerances and mathematical approaches to control of the spider robot positioning for the Tendon Suspended Inspection Robot.

- Dr. Robert Williams of Ohio University worked on the Follow-the-Leader Algorithm for the Serpentine Robot Project.

- Dr. Jonathan Whitlow of Florida Institute of Technology worked on fluid modeling for the ice project.

- Dr. Ryan Stansifer of Florida Institute of Technology worked on building a conversion software model to convert Shuttle GOAL programs to JGOAL software which will allow viewing launch countdown data on any computer connected to the WWW virtually real time.

HEDS Enterprise Objective 4.3:
Involve our Nation's citizens in the adventure of exploring space

- Work in partnership with entities outside NASA to bring the space experience to our Nation's citizens
- Engage our Nation's citizens in the space experience as we open the space frontier

KSC Implementation Plans:

- Expand our cooperative efforts with industry to publicize and promote NASA activities, programs, and mission through:
    - Florida Spaceport Authority
    - Expanded use of the World Wide Web
- Provide speakers for civic, business, and other groups on NASA topics through the KSC Speakers Bureau
- Make effective use of an agreement with the Florida university system to utilize the strengths of the state university system to support resolution of KSC mission-related issues and problems
- On a regular basis, publicize KSC's successes and technologies through television, public speaking, space advocacy groups, etc.

DE Accomplishments:

- Assisting the HEDS Outreach Integrated Communications Team develop a HEDS-wide plan to increase support for Human Exploration and Development of Space. The plan will document "customers" (including the people of the country and their institutions such as legislators, the press, educational establishments, NASA employees, etc.). It will also describe opportunities to increase support within each customer segment and will

prioritize customer segments based on increasing support within non-traditional groups. The outreach effort will not be limited to communications outward from NASA but will attempt to address mechanisms for involving and engaging Americans in NASA's HEDS activities.

- Helped organize a VIP tour of the Kennedy Space Center by attendees of the 38th American Institute of Aeronautics and Astronautics (AIAA)/Airlock Signal Conditioning Electronics (ASCE)/American Society of Mechanical Engineers (ASME)/American Society of Composites (ASC)/American Helicopter Society (AHS) Structures, Structural Dynamics, and Materials Conference.

- Chaired a session on nondestructive evaluation of aerospace systems at the 15th International Modal Analysis Conference held in Orlando, Florida.

- Worked a Cooperative Agreement notice for McDonnell Douglas in developing a rocket proposal for the United States Air Force. Numerous tasks that were accomplished are proprietary.

- Developed a theoretical methodology for a new stiffness based design approach for aerospace structures. This was done under a Graduate Student Research Program grant provided by Georgia Tech.

HEDS Enterprise Objective 4.4:
Join with other nations in the international exploration and settlement of space

- In cooperation with other nations, design an international strategy for exploring the Moon and Mars

KSC Implementation Plans:

- Continue KSC representation at ISS meetings in foreign countries to establish relationships

KSC Future Plans:

- Support Agency initiatives in the development of joint international ground support architectures

DE Accomplishments:

- DE and its ISS contractors maintain continuous relationships with the ISS International Partners, particularly Agenzia Spazile Italiana (ASI) and its prime contractor, Atenia Aerospace, and with the Russian Space Agency (RSA). Atenia is providing numerous GSE end items to KSC through the ISS Support Equipment IPT. Typical activities included requirements definition, design reviews, ICD development, and schedule integration. Over the past year there have been seven meetings either at KSC or in Italy and, as a minimum, weekly telecoms and correspondence. DE representatives have also met with RSA officials on several occasions this year concerning the modification of KSC's Ammonia Servicing GSE for use on the ISS

Science Power Platform. DE representatives have also met with ESA (European Space Agency), National Space Development Agency of Japan (NASDA), and Canadian Space Agency (CSA) to explore GSE commodity opportunities.

SECTION II

KSC SPECIFIC ROLES IN SUPPORT OF THE AERONAUTICS AND SPACE TRANSPORTATION TECHNOLOGY (ASTT) ENTERPRISE

ASTT GOAL 1

Global Civil Aviation: NASA's objectives for improving air transportation system safety, affordability, and environmental compatibility include technology for a ten-fold improvement in the safety of flight, a 50 percent reduction in the cost of air travel, and equally aggressive reductions in aircraft noise and emissions over the next 20 years. Another objective is to reduce the cost of access to space.

ASTT GOAL 3

Access to Space: Low-cost space access is the key to unleashing the commercial potential of space and greatly expanding space research and exploration. Through integration of aeronautical principles with commercial launch vehicles, a ten-fold reduction in the cost of placing payloads in Low Earth Orbit is anticipated within the next decade. An additional ten-fold cost reduction in the decade beyond is the far-term goal for low-cost space access.

KSC Implementation Plans:

- In partnership with the space launch industry, KSC will support the development of an economical, safe, and fully reusable launch system that will meet the future access-to-space needs
- Perform systems engineering and concept analyses, develop ground-based technologies, and validate the performance of key technology products in support of a series of flight demonstrators (X-34 small demonstrator and the X-33 advanced technology demonstrator) to substantially reduce the risk associated with developing a full-scale operational reusable launch vehicle (RLV)
- Through the use of innovative management, cooperative agreements, and procurement mechanisms, actively consider Government and commercial needs in the business and technology planning of the RLV
- Support the development of high-risk, reusable advanced space transportation technology
- Support launch concept definition and architecture studies, including single-stage-to-orbit, two-stage-to-orbit, vertical-takeoff, horizontal-landing, and horizontal-takeoff options using air-augmented rocket, as well as rocket-only, propulsion
- As a member of an Industry/Government Team, develop the technology to dramatically reduce the cost of space access to enable affordable access for commercial and university space technology experiments
- Continue teams efforts to provide safe, efficient, and cost-effective Expendable Launch Vehicle services

- Participate with local industry and provide KSC resources and expertise to promote commercialization and sensor technology (Florida/NASA Business Incubation Center)
- Support development of optimum weather constraints to launch, landing, and ground processing of the RLV

KSC Future Plans

- Perform and participate in advanced studies to determine feasibility, compatibility with launch capabilities, and cost effectiveness of low-cost transportation and payload processing options for future advanced launch vehicles
- Conduct concept analysis for a next-generation, large-scale flight demonstration vehicle to ensure system technology concepts compatibility with current launch site capabilities
- Establish aggressive commercialization programs that successfully transfer NASA technologies to private industry
- Continue to promote and enhance the existing technology transfer program
- Support the definitions and new requirements delineation for new space flight vehicles

DE Accomplishments:

- Provided design and analysis support for umbilical systems for the X-33 Advanced Technology Demonstrator. (See HEDS 1.1)
- Provided evaluations and design concepts for the Evolved Expendable Launch Vehicle Program. (See HEDS 1.1)
- Provided MLP design and utilization data and support for the Boeing Commercial Space Company for the Sea Launch Program. (See HEDS 1.1)

SECTION III

KSC SPECIFIC ROLES IN SUPPORT OF THE MISSION TO PLANET EARTH (MTPE) ENTERPRISE

MTPE ENTERPRISE GOAL 1
Expand scientific knowledge of the Earth system using the unique vantage point of space

MTPE Enterprise Objective 1.1:
Develop the capability to perform repeated global inventories of land use and land cover from space and to develop the scientific understanding and models necessary to evaluate the consequences of observed changes

MTPE Enterprise Objective 1.2:
Develop and use remotely sensed and in situ observations to monitor, describe, and understand seasonal-to-interannual climate variability, with the aim of improving skill in long-range weather forecasts and seasonal climate predictions

MTPE Enterprise Objective 1.3:
Understand the causes and consequences of long-term (decades to centuries) climate system variability

MTPE Enterprise Objective 1.4:
Develop understanding of processes affecting distributions of ozone and oxidizing species in the global troposphere and stratosphere, to determine those distributions, including their spatial and temporal dependents, and to quantitatively characterize observed past and, through the use of predictive models, potential future changes in these distributions

DE Accomplishments:

- Designed, built, and tested a tracking system for the Parabolic Dish Solar Collector Waste Fluid Reduction System (PDSCWFRS). The tracking system is an English equatorial mount design driven in the polar axis to allow tracking of the sun throughout the day and fast slewing back to the Earth each night to position the dish for sunrise. The prototype 4-foot diameter dish is currently being modified to handle waste for CFC reduction. An off-the-shelf commercial astronomical telescope tracking and drive system was adapted to the dish mount without any problems and has also been incorporated into the design of the tracking system for the 12-foot diameter

production dish boiler. The production dish system is currently in the final design and preliminary construction phase.

MTPE Enterprise Objective 1.5:
Understand Earth processes which can lead to natural disasters, develop risk assessment capability for vulnerable regions, and coordinate with U.S. disaster managers and international space agencies

KSC Implementation Plans:

- Continue to develop facility, system, and equipment design strategies, specifications, and technologies that can endure natural disasters with minimal impact to functionality and transfer these technologies to the public and commercial sector

KSC Future Plans:

- Initiate development of a hurricane wind measurement instrument capable of recording wind direction and speeds up to 150 miles per hour (mph) with survivability to 250 mph

MTPE ENTERPRISE GOAL 2
Disseminate information about the Earth system

MTPE Enterprise Objective 2.1:
Implement successive releases of EOSDIS in phase with spacecraft launch schedule

MTPE ENTERPRISE GOAL 3
Enable the productive use of MTPE science and technology in the public and private sectors

MTPE Enterprise Objective 3.1:
Extend the use of NASA's data, models, and research beyond the traditional science community to be applied to the needs of the State, local, and commercial sectors

KSC Implementation Plans:

- Continue to develop facility, system, and equipment design strategies, specifications, and technologies that can endure natural disasters with minimal impact to functionality and transfer these technologies to the public and commercial sector
- Participate with local industry and provide KSC resources and expertise to promote commercialization of sensor technology

KSC Future Plans:

- As a focal point for applied technology, KSC will work as a team member within the Agency, industry, and academia to transfer and apply NASA-developed technology at KSC, within NASA, and to commercial entities

DE Accomplishments:

- Continue to provide support to KSC organizations with the Andros and MAX mobile robotic systems for protective services, HazMat, and other hazardous operations. Modifications have been made in the past year to increase the systems capabilities and reliability.

- Support local and state agencies with technical and operations assistance on robotic issues. Problems associated with mobile remote control robotic systems have become a focus of DE. Efforts have been successful in extending the operational range of the Andros and MAX robots through selection of new antenna technology. DE is working closely with industry to test and evaluate the new systems prior to making a technology transfer to the public and private sectors. Issues being faced this year will revolve around improving the capability of mobile robotic systems and transferring lessons learned to existing new robotic projects. Emphasis will also be placed on encouraging and educating KSC employee's on robotics and automation.

MTPE Enterprise Objective 3.2:
Support the development of a robust commercial remote sensing industry

KSC Implementation Plans and Future Plans:
- Enhance KSC's role as a testbed for remote sensing testing and validation

MTPE Enterprise Objective 3.3:
Make major scientific contributions to national and international environmental assessments

SECTION IV

KSC SPECIFIC ROLES IN SUPPORT OF THE SPACE SCIENCE ENTERPRISE (SSE)

SSE SCIENCE GOAL 1
Examine the content, structure, origin, and evolution of the galaxy and the universe

SSE SCIENCE GOAL 2
Understand the relationship among the Sun, Earth, and heliosphere

SSE SCIENCE GOAL 3
Understand the origin and evolution of planetary systems

SSE SCIENCE GOAL 4
Understand the origin and distribution of life in the universe

KSC Future Plans

- Identify and support the development of promising new technologies that will enable or enhance SSE missions and reduce mission life cycle costs
- Support the definition and new requirements delineation for new space flight vehicles and space science missions

DE Accomplishments:

- Continue to develop and support the development of nongovernmental standards for space systems. These standards [e.g., ISO American Society of Testing and Materials (ASTM), Institute of Electrical and Electronics Engineers (IEEE), etc.] define the requirements for new launch vehicles, spacecraft, facilities systems, and equipment. We have made major contributions to six ISO standards - GSE, Fluid Characteristics, Flight to Ground Umbilicals, Launch Site Safety, Surface Cleanliness of Fluid Systems, and Mission Operations Concept Standards.

EDUCATION, PUBLIC OUTREACH, AND TECHNOLOGY MISSION
KSC supports and implements the education, public outreach, and technology goals for each of the four NASA Enterprises. The goals, objectives, and implementation strategies for these areas are contained in Section VI, “Kennedy Space Center Cross-Cutting Functions.”

SECTION V

DE SUPPORT ACTIVITIES

EXPERT CENTER FOR WORKSTATION MANAGEMENT

Goal:
Provide Agencywide computer workstation expertise and leadership

Objectives:
- Increase the return that NASA receives from our computer workstation investment
- Streamline the inventory management and software/hardware upgrade process
- Reduce overall workstation management costs
- Maximize the use of common solutions to Agency problems

KSC Implementation Plans:
- Deploy and test solutions in a pilot environment with the existing KSC payloads and KSC-installed workstation base as the target
- Provide a NASA Workstation Management Guide and update it periodically as technology and process change
- Develop an effective virtual “Workstation Management Team” to work Agency issues

KSC Future Plans:
- Focus on UNIX workstation management tools and methodologies. This activity will be performed as a part of a teaming with the UNIX Expert Center
- Promote inventory roll-up of all NASA data to a centralized NASA workstation inventory data server in order to reduce the effort associated with periodic reporting requirements
- Continue to evaluate existing and emerging standards

DE Accomplishments:

- Indirectly support all of the Agency's missions, due to mission needs for workstations to perform their tasks. Whether it is budget data, meeting minutes, department memo's, or writing source code, all require some type of workstation.

- Selected to work with the Payloads Directorate in a joint effort to support activities required of KSC as an Expert Center for Workstation Configuration Management and Inventory.

- Developing workstation management tools which can be used by all NASA Centers in the support of configuration management of all NASA workstations. These tools can be used for data calls for the NASA obsolesce budget planning, NASA Year 2000 software planning, NASA Agency software procurement planning, and the Outsourcing of Desktop Workstation Support Initiative.

- Working to consolidate tools across the Agency and making those tools available via WWW page for all Centers to use. The idea is to reduce duplication across the Agency by sharing common solutions for common problems.

- Provides a Configuration Management Integration System for the testing and verification of all tools being developed and/or provided.

EXPERT CENTER FOR INTRACENTER NETWORKING

Goal:
Provide Agencywide, intracenter, computer network management solutions and expertise in the implementation of those solutions

Objectives:
- To increase the return that NASA receives from our computer network investment
- To streamline the processes and technologies and allow the end user increased functionality for reduced cost

KSC Implementation Plans and Future Plans:
- Integrate Intracenter networking requirements from the various Field Centers to develop a phased solution that focuses on maximizing returns early in the process
- Develop tools, standards, and implementation methodologies to allow the timely deployment of NASA standard networking solutions

DE Accomplishments:

- Compromised over 50 percent of the team at KSC that developed the NASA Expert Center for Intracenter Networking (ECIN) Architecture, Standards and Products document. This document is intended to be utilized by the NASA Lead Center for Communications Architecture (LCCA) and the NASA Chief Information Officer as the principal strategy document for the organization and structure of the Agency’s Local Area Networks (LAN's) and Intracenter communications systems. These LAN's are the backbones of virtually all electronic information dissemination by NASA, including public World Wide

Web services and electronic interaction with the public, private, and educational sectors, as well as the conducting of business across all enterprises.

SECTION VI

KENNEDY SPACE CENTER CROSS-CUTTING FUNCTIONS

EDUCATION PROGRAMS

Goal
Serve as a leading national resource for all levels of American education in the advancement of scientific and technical information and expertise

Objectives:

- Develop and implement science, mathematics, engineering, and technology education programs, services, and research opportunities that meet the needs of educators and students at all levels and to effectively communicate NASA's mission to the education community
- Ensure KSC-produced NASA publications and the Kennedy Space Center Visitor Center include more innovative educational exhibits and experiences, including the benefits of NASA technology
- Work with area institutions and Florida Space Institute on joint development projects and research

DE Accomplishments:

- Supports many programs that contribute to elevating science, mathematics, and technology literacy throughout the country. Locally, DE provides mentors for students by participating in the following programs:
    - SEARCH (elementary students)
    - NURTURE (9th through 12th grades)
    - SHARP (summer internship for high school seniors)
    - MESA (job shadowing for high school students)
    - WISE (Women in Science and Engineering, college students)
    - Summer Intern
    - Cooperative Education
    - Stay-In-School

- Visit schools to inform students of career opportunities in science and engineering. They also participate in regional and state science fair judging.

- Participate in the KSC program to donate excess computer equipment to local schools.

- Make contributions to the Shuttle Team Online web site which provides news about NASA and related topics and offers responses to questions posted about work at KSC and career paths. Provide a biography and a field journal on activities and answered e-mail questions from teachers and students all over the country.

- Formed a partnership with Merritt Island High School, Satellite Beach High School, EG&G, Florida Institute of Technology, McDonnell Douglas, and I-NET, to participate in a national robotics competition against over 150 teams from all over the country. The objectives were: (1) to stimulate our high school students to choose careers in math, science, and engineering so that our country will be better prepared to compete in the highly technical world economy and (2) to increase cooperation between Government, industry, and academia. We successfully reached over 50 students in the process; however, only 25 students completed the program. Our team involved over 20 professionals. The students decided on a concept, designed it, and fabricated it within a 6-week period. We attended a regional competition in New Jersey in March and placed 11th out of 35 teams. In the National competition which took place in April at EPCOT Center, the KSC team beat out all other NASA-sponsored teams and finished in 14th place in a field of 113 teams.

- Provide dissemination of space mission through the KSC Public Affairs web page. DE engineers participated in Spanish and English interviews on projects at KSC for television and periodicals.

- High-Tech Training for Individuals with Disabilities (Valencia Community College): Participated in training and evaluation and sponsored disabled students who entered this program and placed them in an engineering environment where they could enhance their knowledge of computer-aided design (CAD) and contribute to KSC's mission by assisting design engineers.

- Designed, fabricated, and assembled a transportable 1/15 scale model of the Space Shuttle for display at the spring training site of the Florida Marlins in Viera. The model was shipped and erected in March 1997. Also, completed fabrication of a second transportable 1/15 scale model that will be used jointly by the TPO offices at KSC and MSFC. The model will be displayed at various NASA functions throughout the country to promote the space program.

- Provided consultation services to HBO representatives during production of the series “From the Earth to the Moon.” Apollo-era drawings, photos, Apollo hardware (including the original White Room), and excess VAFB hardware were provided for the sets.

- Supports Technology Transfer activities across all NASA enterprises active at KSC. Details of the programs are described under the HEDS Enterprise Goal 4.

- Licensed the SSGLCS to two private companies for commercial sales. The SSGLCS utilizes supersonic air-water jets to clean in an environmentally safe manner with very low quantities of dirty effluent. The SSGLCS patent process is progressing.

PUBLIC AFFAIRS

Goal
Promote public understanding of the role the space program plays in enhancing national economical growth and security, preservation of the environment, educational excellence, and peaceful exploration and discovery

Objective:
- Communicate information about NASA’s Enterprise-related activities and successes, including KSC payload processing and launches, to the news media, general public, special public groups, community leaders, and influential national organizations

KSC Implementation Plans and Future Plans:
- Work with various private and public organizations to encourage NASA and KSC exhibits at their location

DE Accomplishments:

- Supported the Public Affairs Office by fabricating training and teaching aids (hand-to-eye coordination fixture, booster flex fixture used to demonstrate the flexing of the boosters at SSME ignition, and a flying wing model used to demonstrate concepts for flying) to be used for demonstration purposes at area schools and universities.
- Supported the Public Affairs Office by providing speakers to the Live Oaks Kiwanis Club in Live Oaks, FL; the Civil Air Patrol in Florence, SC; Coffee High School in Douglas, GA; the Vero Beach Christian Church in Vero Beach, FL; and the University of Georgia in Athens, GA. Some of the topics included: Robotics, NASA’s Strategic Plan, KSC Story, Shuttle and Payload Processing, Space Station, and a discussion of what skills are more

important to employers. The feedback from the community has been excellent with newspaper articles reporting on some of these events.

- Supply escorts to the Public Affairs Office in support of high-profile Shuttle missions. Some of the missions supported this year include: Spacehab (55) and STS 83 with the Micro Science Laboratory. Some of the groups we guided through KSC include the members of the European Space Agency, the Brazilian Ambassador to the U.S., Brazilian Congressmen, and scientists.

ADMINISTRATION AND HUMAN RESOURCES

Goal:
Enhance and sustain a skilled and motivated work force to accomplish the Center's missions, assigned programs, and projects

Objectives:
- Provide essential administrative support and proper skill mix to facilitate work-force accomplishments of Center's missions, assigned programs, and projects

KSC Implementation Plans and Future Plans:
- Ensure that the KSC organizational structure supports Center roles and mission assignments
- Provide employee mentoring, development, and training/cross-training to ensure that an appropriate skills mix is maintained for changing roles and missions
- Implement and maintain systems to recognize and reward employees for superior performance

DE Accomplishments:

- All DE Position Descriptions are filed electronically, which saves time for both the administration office and supervisors when creating new PD's, during reorganizations, and for promotions.
- The DE Approved Training Schedule is updated weekly and is now on the World Wide Web.
- An administrative office manual was developed which describes the administrative processes and identifies the person responsible for each process. This information will be placed on the WWW DE Home Page to assist employees.
- DE personnel were instrumental in improving the employee clearance process by creating a new Clearance Form now used by all Administrative

Offices at KSC. A database was developed and clearance contacts are now notified by e-mail of a clearing employee. In the past, approximately 20 phone calls were made each time an employee left KSC or went on LWOP.

- The DE Administrative Office provides administrative management and advisory services and a centralized administrative support program for the Engineering Development Directorate. We provided extensive assistance in support of the civil service reassessment exercise.

- The DE Training Coordinator assists employees in enrolling for specific training courses that support the Center's mission and maintain training records and histories. Management and employees are advised on the use of rotational assignments to provide the skills mix necessary to accomplish changing goals.
- DE implements the present award system (Time-Off, On-the-Spot, Superior Achievement, performance, and honor awards), advising management, and ensuring that proper recognition is given for superior performance.

APPLIED TECHNOLOGY DEVELOPMENT AND TECHNOLOGY COMMERCIALIZATION

Goal
Promote and transfer NASA and Federal Government technology to commercial enterprises

Objectives:
- Extensively leverage NASA applied research resources in support of launch and other space technology missions to improve safety/reliability, reduce operational costs and processing time, improve customer service, and upgrade existing systems
- Aggressively market NASA technology, technological expertise, and world class test facility use to commercial enterprises
- Assist industry in the development of commercial products and services through easy access to NASA space technology

KSC Implementation Plans and Future Plans:
- Expand and assert KSC’s role in applied research and technology commercialization
- As the Center of Excellence for Launch and Payload Processing, transfer applied technologies, which will reduce processing cost and transfer these technologies to the private sector
- Provide partnership opportunities for other NASA Center’s, other Government agencies, and commercial enterprises to access KSC engineering, facility resources, and technology development expertise

- Actively involve the KSC civil service engineering work force in finding solutions to commercial requests for assistance
- Increase participation of KSC contractor work force in industry assistance efforts
- In partnership with the state of Florida, provide a business incubation center for start-up of high technology businesses with high potential for adapting NASA technology to commercial products and processes
- Continue the performance of applied research to improve materials required in the launch environment
- Continue to support technology transfer efforts in environmental monitoring to enhance sampling and data management

DE Accomplishments:

- Initiated a Space Act Agreement with MVE, Inc. in February 1997 for a "Comparative Study of Cryogenic Vacuum Insulation Systems." The agreement includes testing and evaluation of new materials for cryogenic insulation. The basic goal is to develop insulation systems that will operate in the low vacuum range (above 1.00E-03 torr) with performance that is comparable to multilayer insulation (MLI) systems at high vacuum (below 1.00E-05 torr). New materials from MVE, Aspen Systems, Composite Technology Development, and Cabot Corporation, and combinations thereof will be tested using a cryostat designed by DE and liquid cryogen vessels manufactured by MVE. The new test facility will be located at the Development Test Laboratory. Facility fabrication is nearing completion. The project is scheduled to run from March 1997 through November 1997.

- In conjunction with the Logistics Directorate, completed liquid oxygen impact and flammability testing of aerogel composite insulations in July 1996 and October 1996 respectively.

- Completed the fabrication, installation, and checkout of the Sea Water Immersion Facility at the KSC Beach Corrosion Test Site. This facility will be used to test the newly developed electrically conducting polymer coatings.

- Prepared a display for Aerogel-Based Superinsulation in support of Technology 2006 in October 1996.

- Submitted an abstract entitled "Aerogel-Based Superinsulation" to the program chairman for the 1997 International Cryogenic Materials Conference in December 1996. The paper examines the development of the new superinsulation system, which employs ultra-low density aerogels formed within a flexible, durable matrix. This effort is a collaboration with Aspen Systems, Inc., which developed the superinsulation under a Phase I and Phase II SBIR. In addition, a liquid hydrogen test of the superinsulation was successfully run (in conjunction with the liquid hydrogen test of the taper-lok

connector) at the Development Test Laboratory in December 1996. With a nominal thickness of 1 inch, a temperature difference of 355 to 380 degrees Fahrenheit was maintained.

KSC LABORATORIES AND TESTBEDS

Goal:
Maintain the KSC laboratories and testbeds as world-class resources specializing in the unique aspects of space vehicle processing, launch, landing and retrieval research, development, test, and evaluation for the purpose of serving customer needs

Objectives:

- Anticipate launch site laboratory and testbed research, analysis, investigative, testing, and emergency response requirements and be proactive in the development and maintenance of laboratory and testbed resources that:
    - Contribute to the ability to safely maintain the launch rate
    - Stand ready to quickly respond to operational needs that impede the processing flow
    - Produce equipment which improves operational efficiency, effectiveness, and safety
    - Monitor technology to appropriately maintain KSC's technological currency
    - Prepare KSC to meet future capacity, processing, and regulatory needs
- Maximize the opportunity to collaborate on research and share KSC resources with external entities to reduce the cost of operating and maintaining the laboratories and testbeds
- Maximize the development and transfer of NASA products, technologies, and expertise for application to other Government and commercial programs
- Establish as common knowledge throughout the Government, industry, and academia the existence of the KSC's applied technology development capabilities and resources

KSC Implementation Plans and Future Plans:

- Provide laboratory facilities which are equipped to address the unique aspects of space vehicle processing, launch, landing, and retrieval operations:
    - Instrumentation laboratories, including capabilities in transducer development and testing, data acquisition systems, landing aids, hazardous gas and toxic vapor detection, contamination monitoring, and optical and acoustic instrument development

    - Communications laboratories, including capabilities in advanced networking of voice, video, and data, communications standardization, network security, fiber optics, radio systems, and television
    - Data systems laboratories, including capabilities in the development and maintenance or real-time launch processing checkout, monitor, and control systems
    - Mechanical engineering laboratories, including capabilities in the fabrication and test of a wide variety of mechanical, structural, and electrical/electronic components and systems and the development of ground support applications and "smart" tools involving robotics, artificial intelligence, expert systems, virtual reality, and fuzzy logic
- Expand and encourage the collaborative use of KSC laboratories and testbeds by aggressively marketing the capabilities to other NASA Centers, Government entities, commercial enterprises, and the public at large

DE Accomplishments:

- Conducted on-going test programs at the Launch Equipment Test Facility for the Air Force Titan IV Aerospace Ground Equipment, Titan Lifting Beam Hardware, and the Martin-Marietta Allient Lifting Beams. During this time period, 108 items were processed, resulting in 129 tests conducted.

- Completed the design of a new MPS LOX Pump Test Facility at the LETF. (See HEDS 3.1)

PROCESS ANALYSIS AND IMPROVEMENT

Goal:
To improve overall performance and quality in operations

Objective:
- Utilize KSC experience and capabilities to support organizations in their process improvement activities

KSC Implementation Plans
- Provide assistance in developing performance metrics that facilitate process improvements
- Provide assistance to Center and organizational management in the development of process improvement strategies and appropriate metrics for measuring success

- Develop and offer training in various reengineering methodologies and change management

DE Accomplishments:

- Managed Component Design/Development and Testing Program, which provides new venders for obsolete launch support equipment, better and cheaper mechanical systems, and innovation including kick-off money for technology which is transferred into the commercial sector. Also funded Electrical Sensor development.

- Developed the Project Control Information System (PCIS), which is an on-line database that will aid in the process of developing and submitting budget plans for the POP. The PCIS provides a user-friendly, paperless environment for developing, revising, reviewing, and submitting task description, allowing timely access to status and feedback information.

- Developed the Technology Outreach Information System designed and implemented to aid the process of technology transfer to the public sector in a more responsive and efficient manner.

- Completed a revised customer survey form and is in the process of distributing at the conclusion of each project.

- Developed and maintained performance metrics for the Directorate's budgets in support of various programs across the Center. These metrics are reviewed periodically and assist in identifying potential project performance problems.

INFORMATION TECHNOLOGY MANAGEMENT

Goal:
Promote an effective implementation of Information Technology (IT) consistent with established Federal, Agency, and Enterprise policies, goals, and standards
Objectives:
- Reduce the cost of providing IT services while maintaining effective support
- Provide efficient implementation of Agency IT initiatives

KSC Implementation Plans and Future Plans:
- Provide support and assistance for implementation of Agency IT initiatives
- Promote reengineering of business functions to reduce cost of automaton

ISO PROJECT MANAGEMENT

Goal:
To integrate and focus the Center's ISO certification process

Objective:
- To demonstrate by third party certification the implementation of an integrated quality management system for KSC

KSC Implementation Plans:
- Train management in the ISO requirements for effective leadership of an involvement in the process
- Develop an effective audit, corrective and preventive action system which will be used as a process analysis tool
- Integrate and document all important processes across directorates
- Develop a documentation control system which will facilitate communication and unite cross-functional responsibilities

Future Plans
- To continue to improve activities associated with the management system and retention of ISO certification

DE Accomplishments:

Implementation of the following activities was begun or was completed:
- ISO 9000 Introduction/Awareness Training
- Preparation of a Quality Management System Manual
- Preparation of a new or update of existing procedures related to the quality management system process
- Identification of training requirements
- Identification of quality records
- Trained ISO 9000 auditors

APPENDIX A

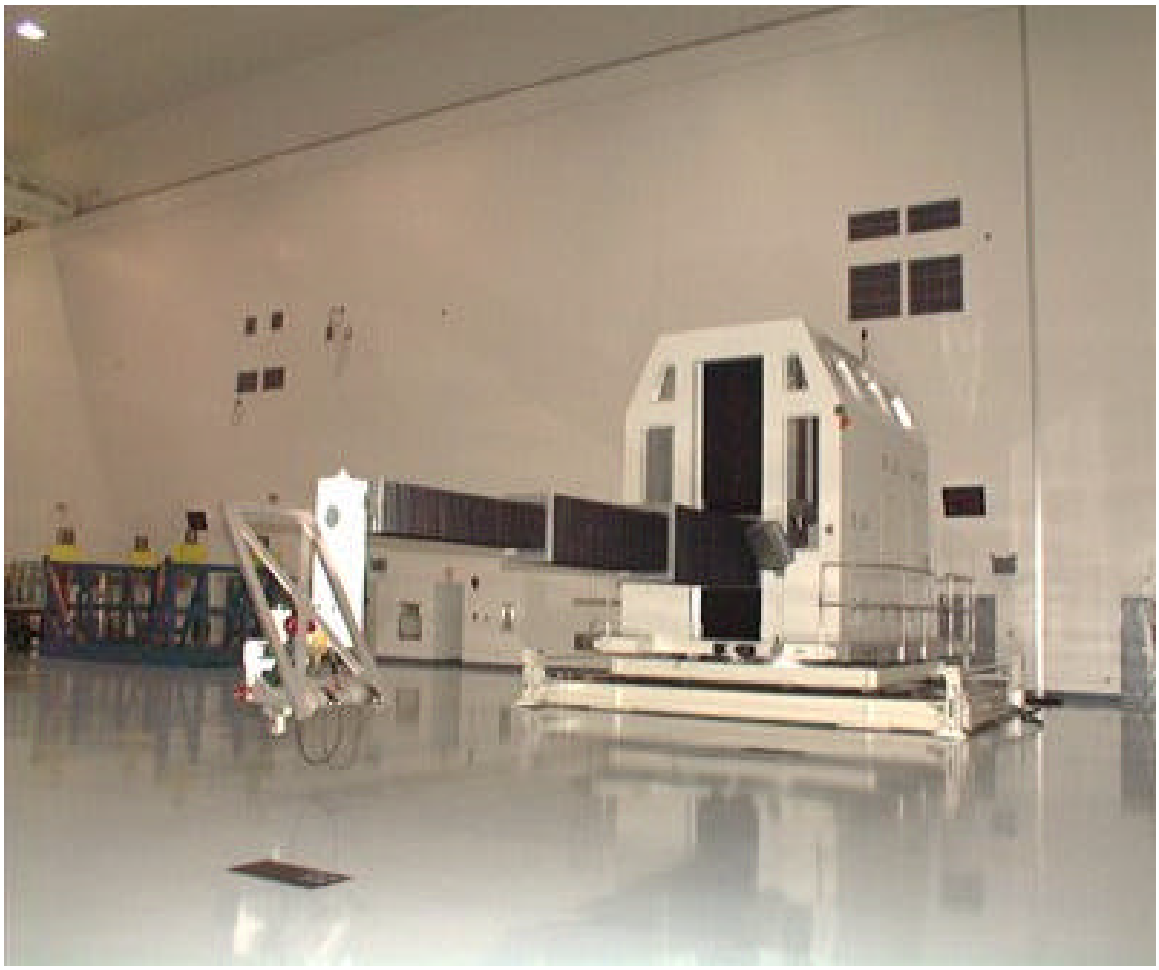

Figure 1. Rack Insertion Device

Figure 2. Center of Gravity End Effector

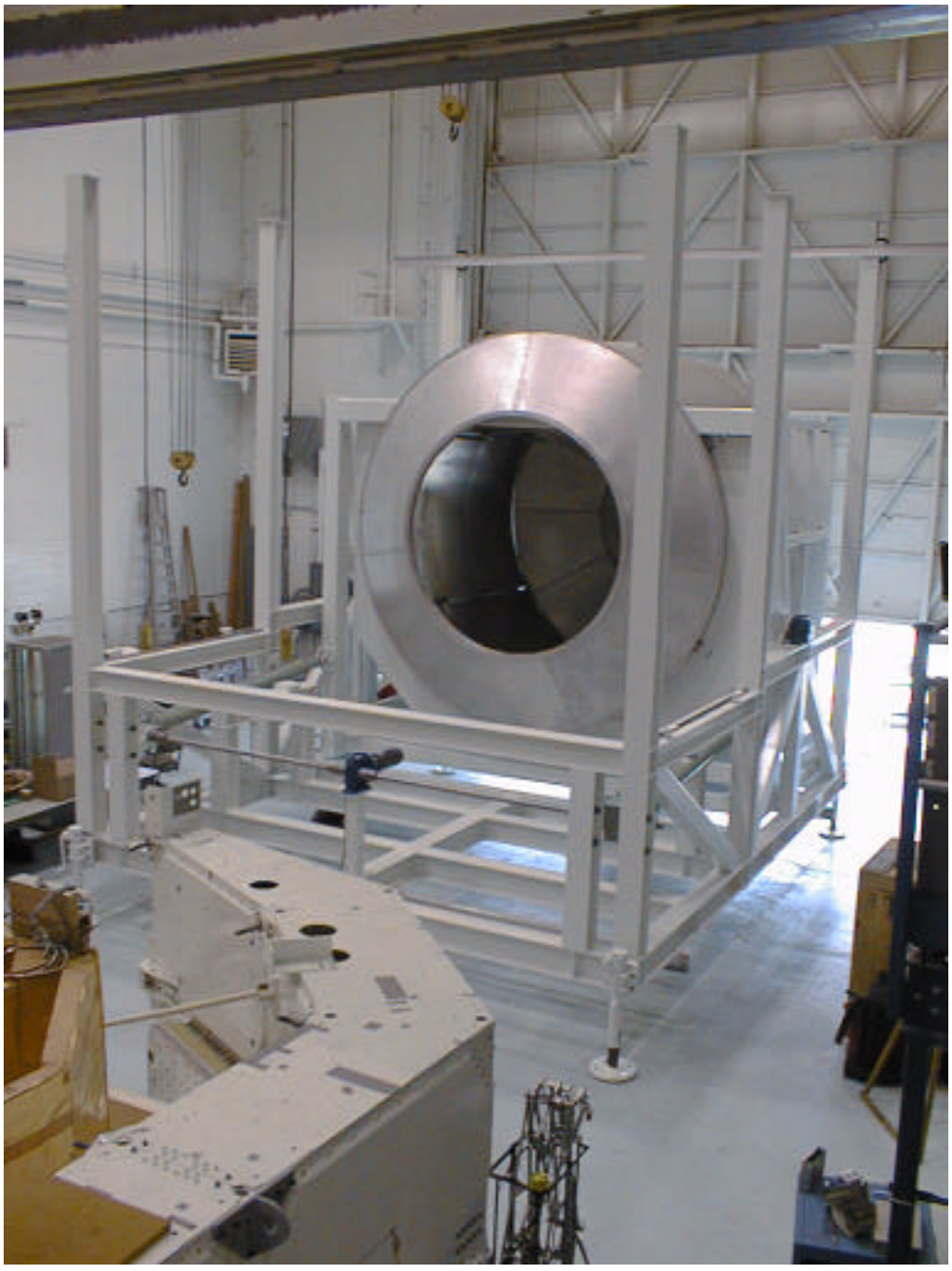

Figure 3. MLPM Access Certification Equipment (MACE)

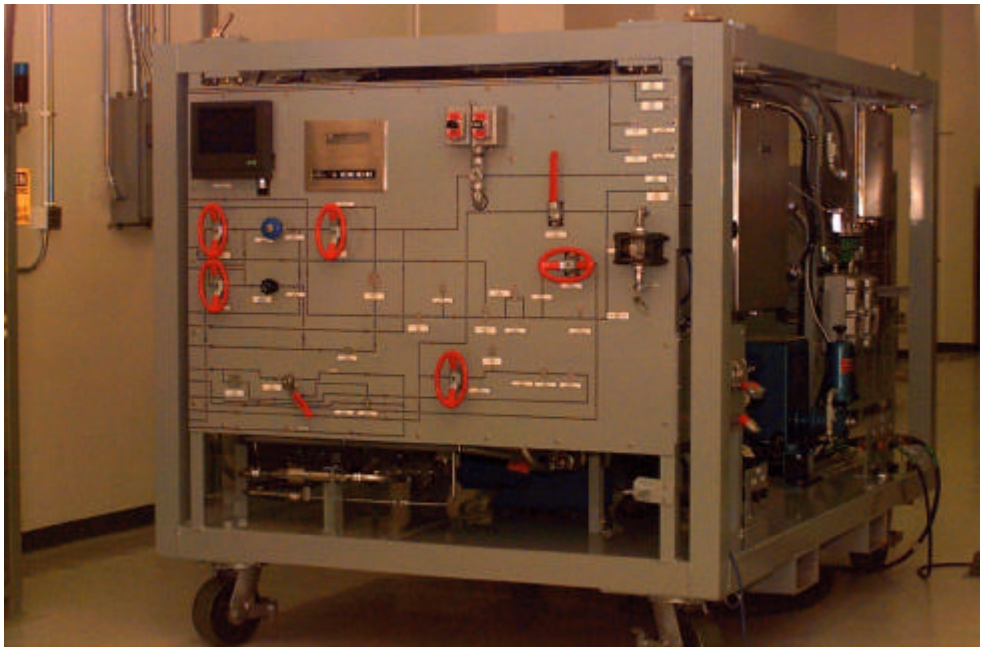

Figure 4. Ammonia Servicing System

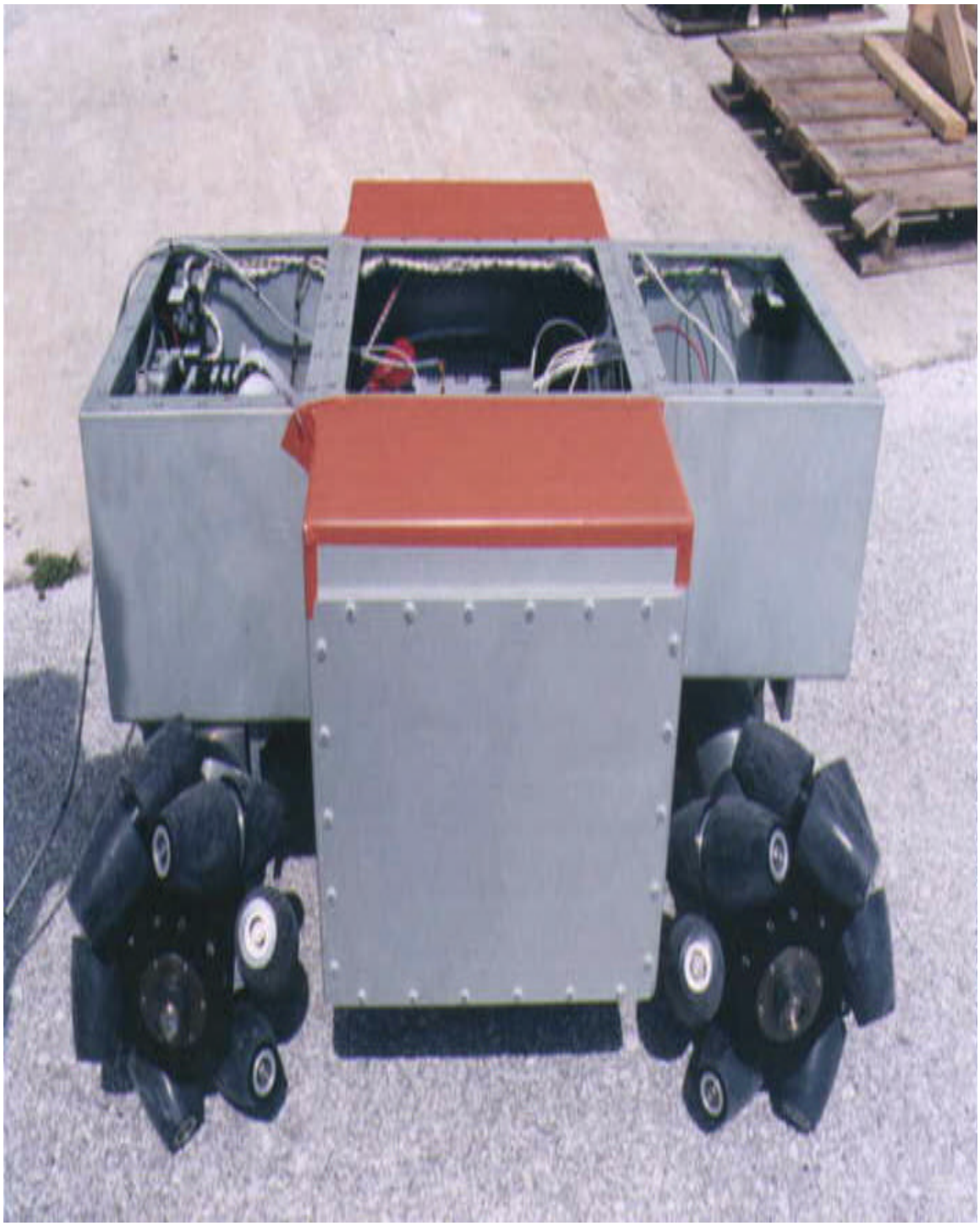

Figure 5. Omnibot Mobile Base

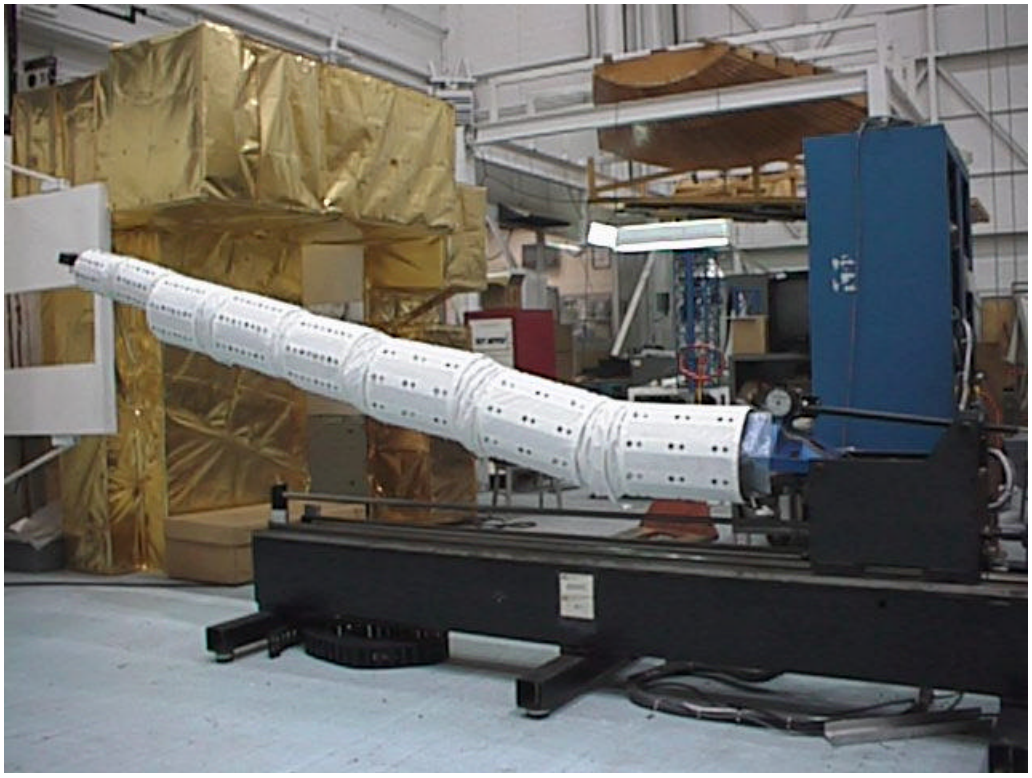

Figure 6. PIPS Serpentine Truss Manipulator

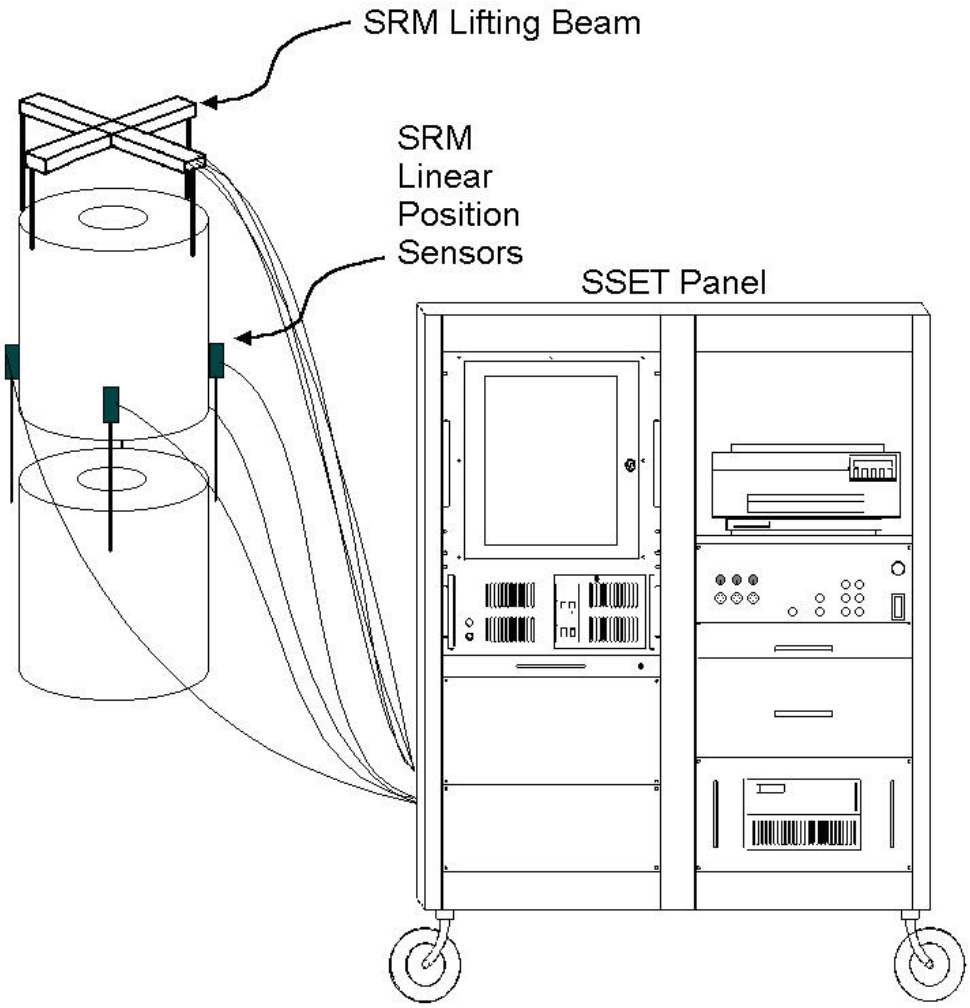

Figure 7. SRM Stacking Enhancement Tool (SSET)

Figure 8. Cryogenic Vacuum Insulation System